UNIVERSITA' DEGLI STUDI DELL'AQUILA
Dipartimento di Ingegneria Civile, Edile-Architettura, Ambientale

Ph.D.ICEAA
Dottorato di ricerca in Ingegneria Civile, Edile-Architettura, Ambientale
XXXII ciclo

REINFORCED CONCRETE IN RESTORATION WORKS OF MONUMENTAL BUILDINGS

Study of the Interventions Conducted among Central Italy and Southern Part of United States in the Twentieth Century

Coordinatore del Dottorato
Prof. Marcello Di Risio

Tutor
Prof.ssa Simonetta Ciranna

Candidato
Ing. Marco Felli

UNIVERSITÀ DEGLI STUDI DELL'AQUILA

DIPARTIMENTO DI INGEGNERIA CIVILE, EDILE-ARCHITETTURA, AMBIENTALE

Ph.D.ICEAA

Dottorato di Ricerca in Ingegneria Civile, Edile-Architettura, Ambientale

Curriculum Ingegneria Edile-Architettura

XXXII ciclo

REINFORCED CONCRETE IN RESTORATION WORKS OF MONUMENTAL BUILDINGS

Study of the Interventions Conducted among Central Italy and Southern Part of United States in the Twentieth Century

SSD ICAR/18 – Storia dell'Architettura

Candidato

MARCO FELLI

Coordinatore del corso

Prof. MARCELLO DI RISIO

Tutor

Prof. SIMONETTA CIRANNA

A.A. 2018/2019

TABLE OF CONTENTS

Introduction and Aims of the Research p. 7

Methodology and Structure of the Work p. 11

Abstract in Italian p. 21

CHAP. 1 Reinforced Concrete as a Solution to the Static Problem p. 25
Development of new Technologies in Restoration since the Beginning of Twentieth Century

1_1 The Areas of Study p. 30
Case studies of the research between Italy and United States

1_2 The Periods, the Reasons of the Restorations and the use of Reinforced Concrete p. 40
Most important phases of restoration in the last century

CHAP. 2 Theories and Laws p. 49
The Uses of New Materials during the Century

2_1 "Before the Rules" p. 54
Use of the New Materials before the International Codes

2_2 Theories and Rules p. 70
Development of rules, laws and theories from the Athens 'Charter to the present day

CHAP. 3 Restoration Strategies in Central Italy p. 79
Study of the realized interventions

3_1 Restoration Typologies and Strategies p. 84
Approaching methods to religious and civil buildings

3_2 Significant Examples p. 102
Case studies in L'Aquila and Marsica

CHAP. 4 Case Studies in United States p. 117
Franciscan Missions in Texas and California

4_1 Franciscan Missions: introduction p. 122
Beginning, development and architecture of the missions

4_2 Analysis of the interventions p. 128
Restorations in the first half of the twentieth century

4_3 Significant Examples in Texas and California p. 138
From the Alamo to the "Queens of Missions"

CHAP. 5 The Structural Aspect of the Restorations p. 159
Study of the structural behavior of the restored buildings

5_1 Introduction p. 164
Acknowledge about the study

5_2 Impact of the restorations p. 172
Evaluations of interventions based on the later status of buildings

5_3 Case study: Basilica of Santa Maria di Collemaggio p. 180
Structural considerations about the conducted restorations

5_4 Analyzed Restoration and Typologies p. 186
Report of the studied interventions

CONCLUSIONS Reinforced Concrete and Restorations today p. 195
Relations and preservation in today's context

Strategic directions of intervention p. 198
Critical evaluations and possible direction of interventions

Conclusions p. 210
Additional researches

APPENDIX Database of the Analyzed Interventions p. 215
Summary tables of the interventions

A Analyzed Restorations in Central Italy
Summary tables of the Interventions among Abruzzo, Marche, Umbria and Lazio Regions

A_1 Case studies in Abruzzo p. 216

A_2 Case studies in Marche p. 290

A_3 Case studies in Umbria p. 308

A_4 Case studies in Lazio p. 324

B Analyzed Restorations in United States
Summary tables of the interventions among Texas and California

B_1 Case studies in Texas p. 342

B_2 Case studies in California p. 350

SOURCES Annotated Bibliography, Consulted Archives and Graphic Sources p. 363

Bibliography p. 367

Consulted Archives p. 401

List and Sources of Images p. 403

INTRODUCTION AND AIMS OF THE RESEARCH

"Bernard Berenson asserts that the research does not write the history, but it gives only material for that, and part of this material is a friable and lousy matter. They are words which well define also the aims and the limits of this work: picking up pieces of history trying not merely to amass shoddy stones" [1].

The historical built heritage of the present day constitutes the result of the continuous modifications from the past. The development of theories, the discoveries of materials, the alternations of natural and human events flowed into what it is the actual form of this heritage.

In this overview, an important role, if not primary, is employed by the restoration works, which handed down this legacy to the present day. After the first theorizations and applications which characterized the 18th century, in the last century the restoration had considerably increased its primary role in architecture, with its development, thanks to the new theories, the international debates, and also the new materials from the technological growth.

As the restoration theories and their applications, also the modern means found in the same period their most important developments and experimentations. One of these means is the reinforced concrete, which strongly characterized the field of architecture, interesting not only the new constructions[2], with the applications pursued by the most important architect in the history of the time, but also the field of preservation. In this last case the conducted research intends to focus on.

The use of reinforced concrete pursued in the restoration of historic and monumental buildings represents a specific approach to the existing which characterized large part of the last century, in which the necessity of preservation increased its role in the society. Inducted by the natural events, such as earthquakes, human factors and also the decay conditions of the built heritage, the efforts of preservation of the last century found in the ruled used of the modern materials, together with also their quick and easy applications, the possibility of reinforcement and recovery. The first thirty years of the 20th century are characterized by the continuous experimentations and development of the applications, since the sample insertion of single elements to the deassemblation and reposition of the existing structures, with the insertion of skeletons in entire buildings.

The research had been conducted among different areas, aiming to identity common aspects related to the application of the modern means: Italy and United States. Both areas have different common aspects: both of them are characterized by a diffuse experimentation in the first thirty years of the 20th century, due to the needs of reconstruction and reinforcement induced by the natural destroying phenomena which interested the areas, such as the earthquakes. Reinforced concrete insertions represented also the solution to the lack of resistance of the existing architectures, aiming to reinforce them and preserve for the following destroying events. In this way, the study had been focused on the central Italian areas which have been hit by strong earthquakes, such as the territories of Abruzzo, Lazio, Marche and Umbria. Instead, the American case studies have been related also to the possibility of the physical comparison and analysis: indeed, part of the research had been conducted at The University of Texas at San Antonio (UTSA), in which it had been possible to study and analyze the restoration campaigns pursued in Texas and California on the Franciscan missions, which represent some of the most important monumental architectures of the areas.

Reinforced concrete owed its success in the first half of the twentieth century to two main technical reasons: structural effectiveness (resistance to traction and bending actions) and plasticity (intended as capacity of the material to take different forms). However, more complex reasons led to the widespread use of this material in restoration. The theories of restoration of the epoch, in particular those of historical-philological and scientific restoration, affirming the concept of conservation and recognizability of the interventions, supplied a theoretical legitimacy for the new material. It allowed one to perform purely technical and functional interventions. It was clearly recognizable as modern and it stood out from the original materials of the building, not giving cause to falsifications. It was a material “without history” which allowed one to carry out neutral interventions from a stylistic point of view. As a consequence of the division that occurred at the end of the nineteenth century between the artistic–formal and technical–functional aspects of buildings, structures began to have a purely functional role[3]. The strategic and technological importance relating to the use of concrete in restorations assumes a fundamental role, intended as a synthesis of two key aspects of conservation: the esthetic one, which depicts conservation work as a "critical act" for the building's preservation for the future, and the structural one, addressing the study of the building's mechanical properties in order to withstand the stresses due to different possibilities.

The research found the starting point also in the development of the experimentations and patents, then also in the development of the restoration theories. After the discoveries about the potential use of the new material[4], the patent of Hennebique in 1892 certified how the new system, with the joining of beams and columns in monolithic elements, became revolutionary, bringing lot of transformations in the field of constructions. Since its beginning, the new material found its widespread use all over the world, thanks to the different efforts which involved its use. Italy started to became one of the most interesting field of tests of reinforced concrete's applications, becoming interested also in the restoration and recovery works[5]. The impact of the new material, after the first experimentations, interested large part of the Italian context and also other areas of Europe and United States, being applied in comparable ways and neglecting the typologies of masonry on which it had been inserted[6]. While in Europe the use of the material spread thanks to the development of the theories and experimentations, in America the presence in the territory of the cement companies, which constituted, and constitute still nowadays, large part of the economical power of the federal government, increased the use of the modern means. Also, the beginning of the international debate about the new materials in restoration, accompanied by the development of rules and restoration theories, carried an important role in the spread of the applications, whose turning point is represented by Giovannoni's theories and, in particular, the released of the Athens' Charter for the Restoration of the Monuments in 1931. The material found its spread also thanks to the destroying events which interested the research's area, such as the earthquakes and the world wars, which upset entire cities with the bombardments[7].

The diffusion and development of the modern means found only in the last decades the first critic evaluations about the impact and the approach on the historical existing heritage, and the efficiency of the methods, involved in particular by the decaying phenomena of the materials and the more recent earthquake events, from the Eighty Years to the present day. In particular, the last quake events, which characterized the recent history of Italy and California, involved serious damages to the structures, with collapsed when involved by the strongest event. The monumental buildings, therefore characterized by the presence of a mixed masonry/reinforced concrete structure showed in these recent events a huge level of damage[8].

In this overview, the research intended to provide a broad analysis of the interventions in the specific areas, aiming to identify the theories, the elements and the approaches pursued; the realization of synthesis forms, which are reported in the appendix of the dissertation, constituted the starting target of the research, thanks to which it had been possible to proceed with the other analysis and studies. The related study of the historical development, with the theories, and the detailed analysis of some interventions let to understand the development during the entire century, until the present day. In particular, the analysis also of the structural impacts of the interventions constitutes another key point, aiming to individuate the peculiarities of the interventions relatively to the form and the architecture, as much to the structural field. in this way, the thesis aims to individuates some critical evaluations, both on the formal impact of the applications than to the structural effects due to the alterations of the built organisms.

notes

[1] Miarelli Mariani, 1979 (Introduction)

[2] With the continuous development in the architecture applications, from the first modern examples, but also in the technological aspects, which brought to the experimentations of the prestressed or prefab concretes.

[3] Calderini, 2008.

[4] With the progressive development of chemistry experimentations, from the end of 18th century to the beginning of 19th century, some French scientists, as Lavoisier, Vicat and Le Chatelier, with some British technicians, tried to understand the different roles of the components of concrete, focusing the attentions on their relations; one of the endpoint of their research can be found in the patent of the Portland concrete, licensed by Adspin in 1824. The researches on concrete continues until the end of the 19thcentury, in which the development of technologies, with also the availability of modern machinery able to mix up the concrete with the inert elements let the use easier and more comfortable.

[5] The first patents were performed by the Italian engineer Giovanni Antonio Porcheddu, which improved the existing system with the bend of steel bars, thanks also to the agreement among the Studio of Engineers Ferrero & Porcheddu and the engineer Giovanni Narci, head of the Italian Agency of Maison Hennebique (Calderini, 2008).

[6] As analyzed in the case studies, the insertion of reinforced concrete additional elements had been pursued Indifferently in structures made of masonries, stones, adobes or bricks.

[7] In particular WWII, in which lot of cities, as for example in Italy, were severally bombed by the Anglo-American army, losing lot of the historic architectural heritage.

[8] For example, the earthquake of L'Aquila 2009, which destroyed large part of the city center and involved several damages to the historical architectures, constitutes one of the possible case studies which show how these kind of structural reinforcements, restorations and renovations influenced negatively the behavior of the buildings.

METHODOLOGY AND STRUCTURE OF THE WORK

The research activity has been divided in more phases, in such a way as to have a schedule organization of the work in the three years of the doctorate: according to this schedule, each phase constitutes the starting point of the following one.

The starting point of the research is characterized by the analysis and the study of the most important theories and reference codes of the interesting period, the most important conferences, meetings and publications, in which it is notable as the new experimentations in reinforced concrete influenced the debate of the period, being used in the first restoration works on historic buildings. Also, the identification of emblematic case studies constitutes an important element of this phase. Also, according to the different phases of the study, the dissertation has been organized in the chapters, in which all the aspects related to the topic of the research have been taken on.

After the examinations of the general directions of research about this kind of interventions, according to the first bibliographical and archival analysis, there have been individuated case studies, related to specific restoration interventions performed to historical and monumental buildings. From the initial screening, there have been individuated some of the interested interventions which must be focused in details, with deepener and more specific bibliographical and archival studies, in a way to increase the acknowledge of the pursued restoration interventions and individuate both the formal than the structural aspects correlated to the interventions. The analysis of the historical archives of the central Italy (in particular of Soprintendenza and Genio Civile[9] beyond the private archives of engineers and companies) and of the southern part of the United States (such as the historical archives of the National Park Services and the General Land Office[10], beyond the private archives) let the direct study of the restoration projects, in a way to understand the approaches and the pursued methods.

The restitution of synthetic forms about the analyzed interventions, with the individuations of the areas, the context the bibliography, represent the first step of the entire research. In the following phase, the restorations are analyzed completely, evaluating also the problematics emerged in second times, after the realized interventions[11]. This particular analysis represents one of the turning point of the research, trying and also aiming to make some critical considerations about the formal and structural impact of the realized interventions[12]. In the last phase, the aim is related to the identifications of the critical situations in which the intervention in reinforced concrete involved problems on the buildings, with, also sometimes, new needs of reinforcement and recovery. In this phase, the analysis of some of the interested case studies, which had been subjected to other phenomena which involved new restorations, can be emblematic for the conclusions and the additional researches of the dissertation. This last phases, also, aims to define some of the directional purposes for the next restorations. Resuming, there have been individuated different phases of the research. In particular:

1. Historical research and study of the theories

In this phase, which can be considered preliminary to the research, there are individuated the documents which largely influenced the use of reinforced concrete in restoration works during the 20th century. In particular, this phase intends to analyze also the most important congresses and conferences and their influence in the cultural context of reference.

2. Individuation of case studies

According to the bibliographical and archival research about the topic, there are individuated some case studies. Starting from Abruzzo, the research has been extended also to the neighbor regions, such as Lazio, Umbria and Marche. After the individuation of the different possibilities of research, every selected buildings started to be analyzed, according to the related realized restoration intervention, evaluating the possibility of insertion in a general database [13]. In this part of the work and research, it has been inserted also the research that had been conducted in parallel at the University of Texas at San Antonio, identifying also some Franciscan missions in Texas and California, aiming to analyze the restoration works pursued with comparable approaches and technologies.

3. Drafting of analysis forms

For every selected intervention it has been realized a concise forms of analysis; in this part of the works there are summarized all the useful information about the building, the reference context, the used materials and the realized restorations, focusing in particular on those which interested the application of reinforced concrete systems[14]. Among the analyzed restorations, the ones which are part of the research are studied in detail, in a way to understand also the protagonists of the interventions, as the clients, the companies and the designers. Completing this phase, the general obtained database represents the starting point of the other analysis.

4. Individuation of typologies of interventions and first groupings

After the realization of the concise forms, all the reported interventions are reported and grouped in different cases which, according to the area of interest and also to the performed approach, can give more information about the reference periods of restoration and the development of the approaches to the historical buildings.

5. More deepened study of some interventions

Completed the creation of the forms, some of the individuated buildings are selected in a way to focused on them, with the analysis of the intervention typologies and the approaching methods, thanks to specific historical bibliographical and archival researches, aiming to reach more details about the interventions. This analysis had been pursued in each area of interest (central Italy and United States), trying also to understand the cultural context on the restoration interventions.

6. Analysis about form and structure

In this phase of the research, according to the collected and resumed material, it is possible to make some evaluations about the structural aspects of the restorations and their relation with the existing buildings with their applications. Also, the structural and formal comprehension of the impact of the restorations involved the research to the definitions of some critical aspects, on which it is necessary to make some considerations.

7. Critical evaluations

This phase aims to evaluate and verify the subsequent problems of the restored buildings after the restoration interventions[15]. Focusing in particular to the impact of restorations nowadays, this phase aims to individuate the emerged problems relatively both to the structural and formal aspects, in a way to make some considerations about the modifications and damages inducted by the restorations. In the phase, the study of the new rules about the restoration interventions, the studies of the application of modern materials in historical buildings have a fundamental role, in a way to understand also the possible developments of the research.

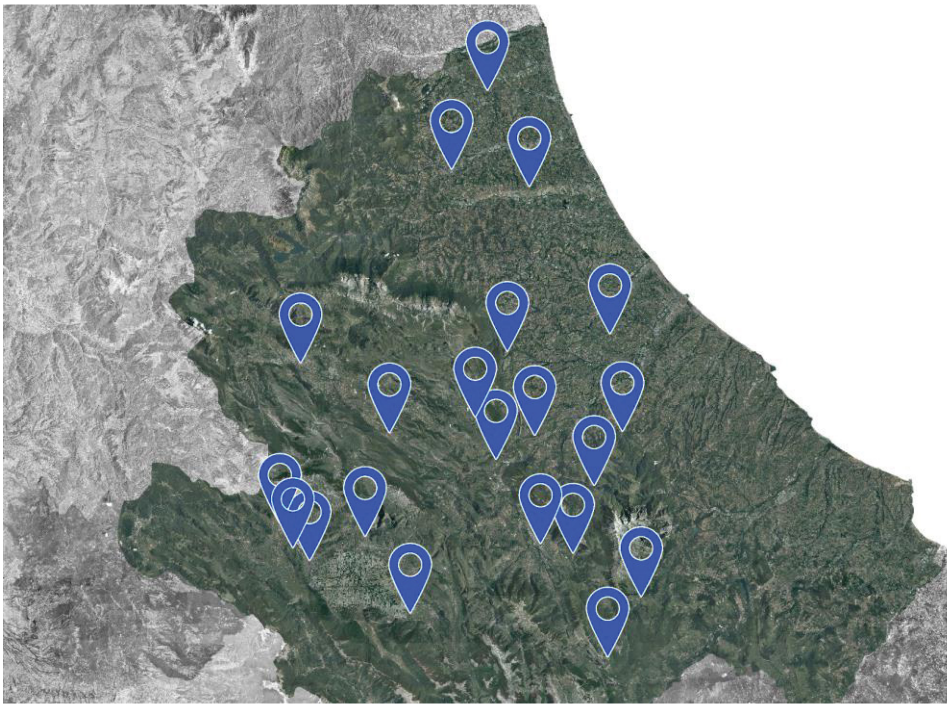


Fig. A_1
Analyzed case studies of Abruzzo

Fig. A_2
Analyzed case studies of Marche

Fig. A_3
Analyzed case studies of Umbria

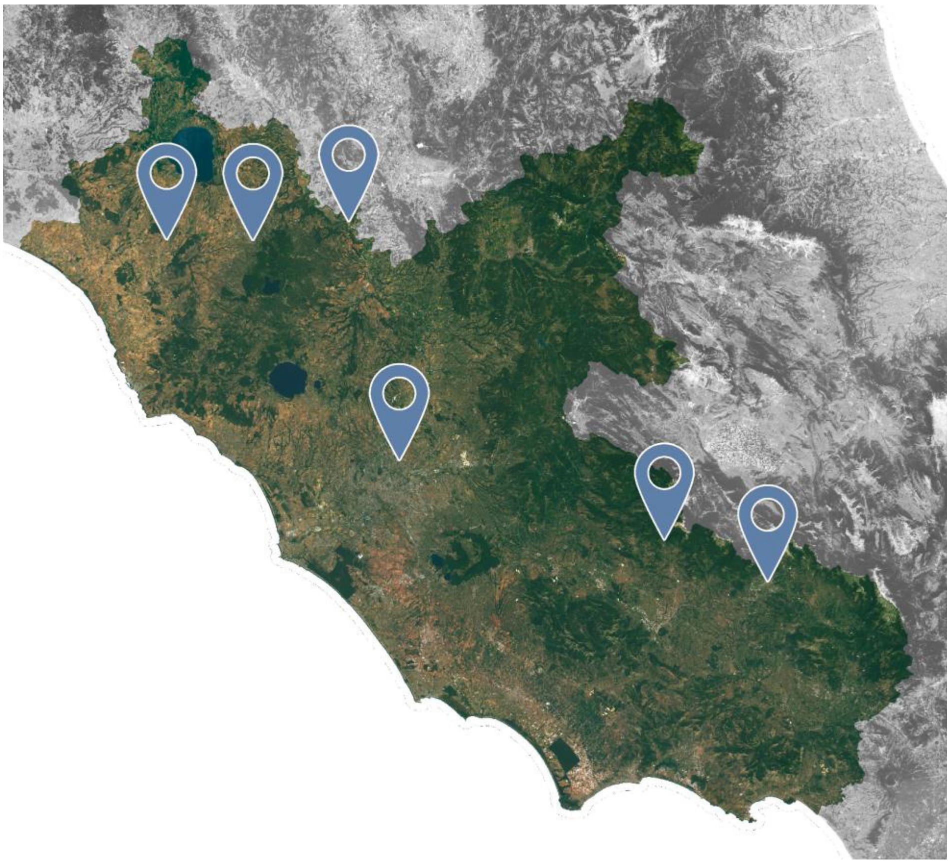


Fig. A_4
Analyzed case studies of Lazio

Fig. B_1
Analyzed case studies of
Texas

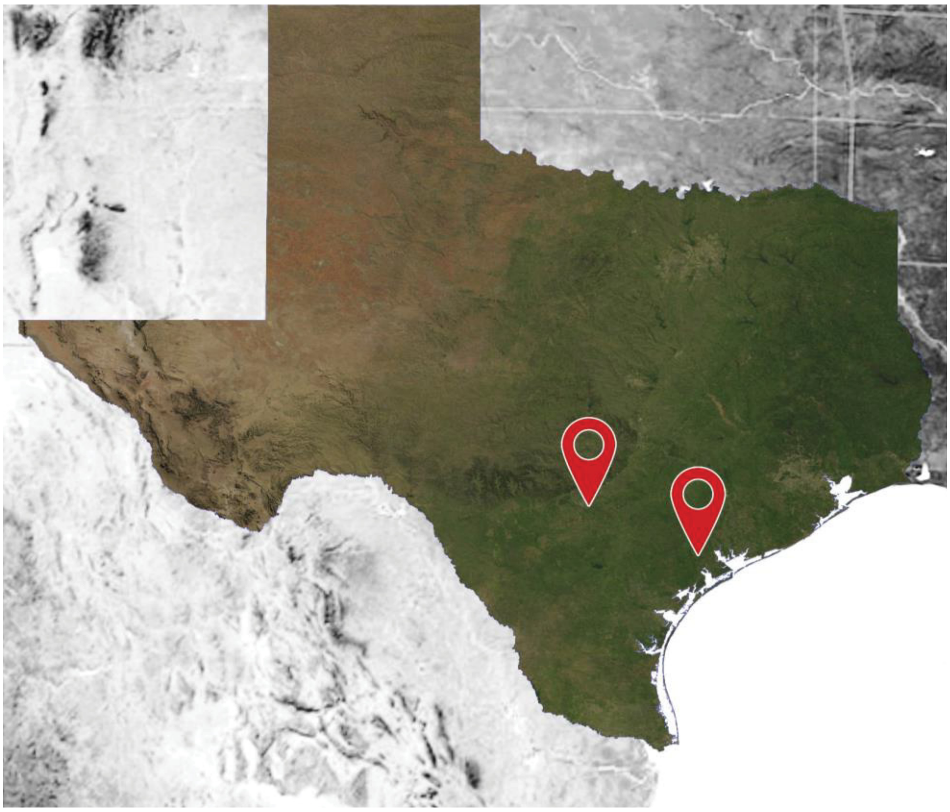
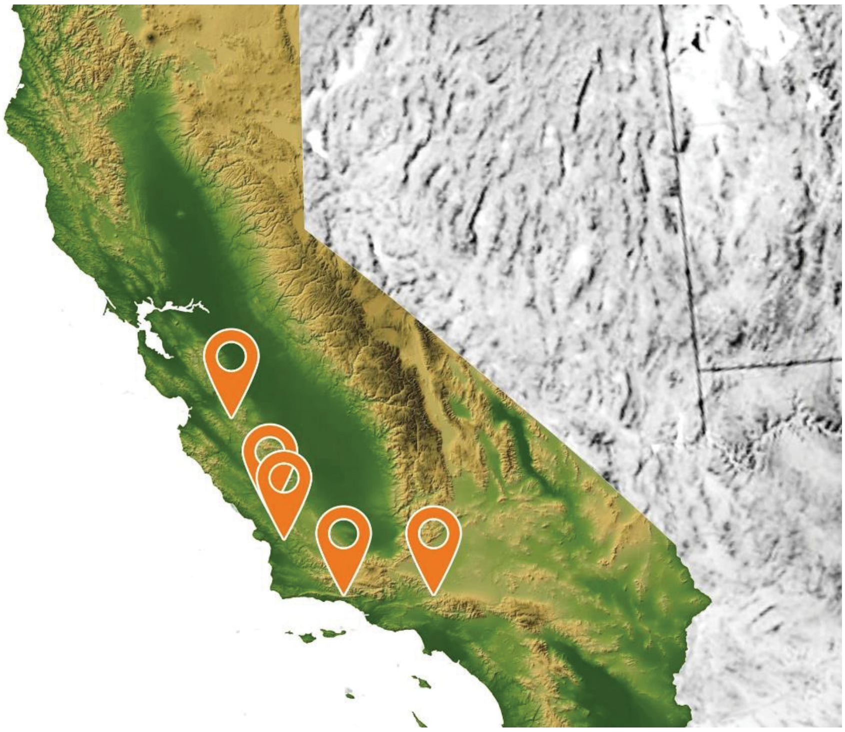


Fig. B_2
Analyzed case studies of
California



With the division of the work in these different phases, pursued in the three years of the Ph.D. research, the present dissertation aims to follow the same division and target, being divided in more chapters. In detail:

- CHAPTER 1 - Reinforced Concrete as a Solution to the Static Problem

The first chapter aims to provide a general overview of the research activity, with the introduction of the study topic. The study areas are identified, with reference to the Franciscan missions of the southern United States, and the periods in which the restoration campaigns begin (from the early twentieth century with the experiments in Italy, until the second post-war period). International movements that favor the technological development of reinforced concrete in the restoration of monuments are also identified.

- CHAPTER 2 - Theories and Laws

The chapter specifically examines the evolution and use of modern material in the various experiments in restoration, from the early twentieth century, in the general Italian panorama. Some of the main figures in the debate are introduced, such as Boito and Giovannoni, as well as other prominent personalities at local level (Gavini) who start the first experiments. The various international documents relating to the debate are also analyzed, such as the 1931 Athens Charter and subsequent Italian restoration maps, the Venice Charter and the American Secretary of the Interior's Standards. In parallel, the evolution, in American soil, of the various entities used to protect the built heritage is reported.

- CHAPTER 3 - Restoration Strategies in Central Italy

The major restorations which certify the use of the new material in the structural recovery of monumental buildings are reported in the chapter, entering into the merits of the interventions (with the description of some projects taken as a sample) of central Italy. The interventions carried out in Santa Maria di Collemaggio (from the post 1915 intervention by Gavini-Biolchi, to the sixties with the restoration of the Civil Engineer and Moretti) and the church of San Pietro in Albe (damaged by the earthquake of 1915 and recovered in the 1950s under the direction of Delogu)

- CHAPTER 4 - Case Studies in United States

Unlike the previous chapter, the case studies studied on American soil (Texas and California) are reported in this case, focusing on Franciscan missions. After explaining its origin and construction, the various restoration campaigns at the turn of the 1930s are examined, with the main works carried out. Here too, some of the interventions are analyzed in more detail: the restoration of the Alamo (former mission of San Antonio de Valero) and of the mission of San Josè y San Miguel de Aguayo (both in Texas) and the mission of Santa Barbara in California, affected by structural remediation after the violent 1926 earthquake.

- CHAPTER 5 - The Structural Aspect of the Restorations

The chapter intends to analyze the problems inherent in the use of concrete in relation to the structural impact on existing masonry products. Specifically, after an introductory part relating to the structural aspects of masonry buildings and the complexity of behavioral assessment of those mixed in masonry with reinforced concrete elements, as well as the lability possible during seismic events, some examples are reported, taken from the restorations already analyzed previously, in which, years after the interventions in concrete, improvements were necessary. In detail, there are also those buildings which, on the occasion of new earthquakes, showed high vulnerabilities, some of which were due precisely to the interventions carried out. Specifically, the state of damage of the basilica of Collemaggio dell'Aquila during the 2009 earthquake is analyzed in a special paragraph, identifying the impact of the previous restorations (Gavin, Civil Engineer, Moretti) on the earthquake response mechanisms. At the end of the chapter, some considerations are reported for all the case studies addressed (about 70 interventions, reported in the appendix in the various summary analysis sheets) according to the implementation period, reasons that led to the interventions and types of intervention relatively to the artefact (local or global interventions)

- Conclusions - Reinforced Concrete and Restorations today

The conclusions are divided into two different paragraphs, gathering the critical observations on the conducted restorations. It is also highlighted that any strategic choices for improvement should also be assessed in consideration of the historicization of the interventions themselves, and therefore placed under the critical assessment of today's restoration theory. The second part of the conclusions focuses on further research developments, articulated in different scenarios.

- APPENDIX - Database of the Analyzed Interventions

The appendix is formed by the analyzed restoration interventions, divided among the different areas of study. Every interested area is analyzed with the creation of sample forms and tables, in which there are briefly provided some of the information related to the analyzed restoration interventions. Also, the reported interventions of the appendix are mentioned during the dissertation, specifically for each of the case studies presented, in a way to reference the specific forms for the analyzed restoration.

notes

[9] Soprintendenza is the national authority related to the preservation of the historical and cultural heritage, while the Genio Civile is the corporation of engineers designated for the protection and the structural evaluations on the general and public constructions.

[10] The National Park Service and the General Land Office can be compared to the Italian Soprintendenza and Genio Civile, showing more or less the same purposes.

[11] This case is related to the possibility of new necessities of interventions in the restored buildings in which, among the new reasons of the applications, the previous works involved some of the emerged problems.

[12] Taking as references the documented case studies in which the realized interventions involved modifications to the structural behavior of building – analyzing some case studies exposed to new destroying events - and, in some cases, also in the formal appearance and evaluations of the buildings after the modifications.

[13] In some cases, a single building can be interested by different interventions, and also different interventions which present reinforced concrete applications.

[14] For every intervention it has been reported also specific bibliography and archival sources.

[15] This analysis had been pursued only in the cases in which it had been certified the impact of the reinforced concrete additions in the global behavior of the structure and in the new relations –structural and also formal - among the materials.

ABSTRACT IN ITALIANO

Il patrimonio costruito rappresenta il risultato di un continuo e ininterrotto divenire, caratterizzandosi dall'alternarsi di eventi che, in parte diretta o indiretta, ne hanno influenzato la propria evoluzione. La conoscenza del costruito storico, tramite il ruolo fondamentale di storia dell'architettura e restauro, trova nell'approccio conoscitivo critico il proprio punto di partenza, permettendo di fare le opportune valutazioni dell'oggetto dell'arte e inquadrarne il proprio stato. In particolare, le conoscenze e lo sviluppo della tecnologia degli ultimi due secoli hanno permesso di porre in risalto questo primario aspetto nello studio del costruito, dai cui risultati muove il progetto di salvaguardia e risanamento.

Partendo dalle realtà ormai già consolidate nell'Ottocento con le prime sperimentazioni e i primi veri dibattiti sul restauro, mossi in particolare dalle posizioni e le sperimentazioni di Ruskin e Viollet Le Duc, il Ventesimo secolo vive sin dai primi albori il consolidarsi delle teorie conservative, guidate dai principi filologici e scientifici di Camillo Boito e Gustavo Giovannoni. La loro presenza nel panorama e nel dibattito italiano, in particolare l'ultimo, favoriscono e *aprono* il restauro verso le nuove tecniche operative e metodologiche fornite dallo sviluppo tecnologico; tra queste, il calcestruzzo armato ottiene un ruolo di primaria importanza, al punto che, sin dalle prime sperimentazioni e i primi brevetti del sistema Hennebique, trova larga diffusione e utilizzo non solo nel campo delle nuove costruzioni, ma anche in quello del restauro e del recupero: in particolar modo, la grande capacità meccanica e di resistenza offerta dal materiale, unitamente alla facilità e versatilità nella posa in opera, ne suggeriscono un utilizzo anche nel rinforzo strutturale di edifici storici dalla natura statica precaria o compromessa, trovando diffusione a livello globale anche e soprattutto in seguito ai fenomeni sismici di elevata intensità che caratterizzano i primi anni del secolo.

In questo contesto, gli edifici monumentali, spesso caratterizzati da un continuo divenire e modificarsi dell'apparecchiatura costruttiva, nella sua interezza duale materica e formale, rappresentano gli idonei casi di studio su cui, a partire dall'inizio del XX secolo, sono stati portati a termine diversi interventi di restauro e

risanamento strutturale, sperimentando i diversi apporti teorici e strumentali offerti dalle nuove tecnologie costruttive del tempo, via via perfezionatesi.

La ricerca condotta intende quindi soffermarsi e analizzare gli aspetti teorici e metodologici relativi all'utilizzo del materiale moderno nel restauro dei beni storici monumentali per tutto l'arco di secolo, dalle prime sperimentazioni immediatamente seguenti i brevetti dei sistemi intelaiati, fino ai modi di operare consolidati tipici del secondo dopoguerra, grazie a cui il calcestruzzo armato trova larga diffusione non soltanto nei territori direttamente colpiti dalle esigenze di ricostruzione e risanamento strutturale degli edifici, ma anche negli altri contesti, nazionali e internazionali, subentrando come vero e proprio modus operandi negli interventi di restauro. Il presente lavoro ripercorre e riflette le modalità perseguite nella ricerca, proponendo dei continui parallelismi tra le aree maggiori di studio, approfondite in due distinti sedi universitarie: il contesto italiano, relativamente ai casi di studio analizzati nell'Italia centrale, presso l'Università dell'Aquila, e i vari archivi storici di enti pubblici, quali Soprintendenza e uffici del Genio Civile, e archivi privati di tecnici e imprese, e quello americano, relativo ai casi di studio individuati nell'area a Sud degli Stati Uniti d'America, in cui sono state perseguite nel corso del secolo delle analoghe e coeve campagne di restauro rispetto al caso italiano, e approfondito presso *The University of Texas at San Antonio* e, come nel caso precedente, presso gli archivi storici degli uffici pubblici e enti privati.

In questo modo, il lavoro è stato articolato in diversi momenti, in modo tale da avere una gestione consequenziale delle varie fasi di lavoro e valutare, procedendo man mano con gli approfondimenti e le analisi, le situazioni in cui sono state riscontrate analogie e parallelismi tra le diverse aree di studio. Nel dettaglio, la ricerca condotta nell'Italia centrale è stata focalizzata soprattutto sulle aree interessate nell'ultimo secolo da fenomeni sismici di intensità tale da indurre livelli severi di danneggiamento: l'individuazione dei casi di studio in Abruzzo, Lazio, Marche e Umbria ha permesso di valutare e indagare le diverse metodologie di intervento, con l'inserimento di nuovi elementi in cls all'interno dell'organismo esistente, e la loro evoluzione temporale. Diversamente, l'area a sud degli Stati Uniti ha riguardato territori morfologicamente e *geologicamente* differenti, Texas e California, caratterizzati però sia da tipologie di architetture monumentali comparabili tra loro, le missioni francescane, che da interventi di restauro e risanamento strutturale perdurati nel secolo.

Le fasi di ricerca pertanto sono state articolate in maniera successiva tra loro, cercando di mantenere uno svolgimento *in parallelo* tra le due aree di studio:

a) Ricerca storica e studio di teorie e normative. La prima fase, preliminare all'intero lavoro, è largamente caratterizzata dalla conoscenza dello stato dell'arte, con particolare riguardo agli studi sui materiali moderni e al loro impatto nel campo del costruito, nelle opere ex novo e in quelle esistenti, sia nei brevetti che nelle prime applicazioni. Inoltre, la fase è stata incentrata sulla conoscenza e l'approfondimento del dibattito teorico internazionale, dai cui diversi incontri sono state enunciate le teorie che hanno largamente influenzato il restauro della prima metà del secolo.

b) Individuazione dei casi di studio. In base alle prime indagini bibliografiche e di archivio, sono stati individuati i diversi casi di studio, per le specifiche aree di ricerca; ciascuno degli edifici selezionati è stato ulteriormente approfondito con le specifiche indagini sugli interventi di restauro attinenti, in maniera tale da ottenere, al termine dello studio dei casi di studio, un database generale comprensivo di tutti gli interventi catalogati per periodo e tipologia.

c) Redazione delle schede di analisi. Per ciascuno degli interventi selezionati è stata redatta una scheda sintetica di analisi, in cui sono state inserite tutte le informazioni sull'edificio, periodo di riferimento, contesto, descrizione dell'architettura, e sullo specifico intervento di restauro riscontrato, con informazioni sui lavori, tempi, progettisti e imprese, e sulla tipologia di inserimento di elementi in cls riscontrata.

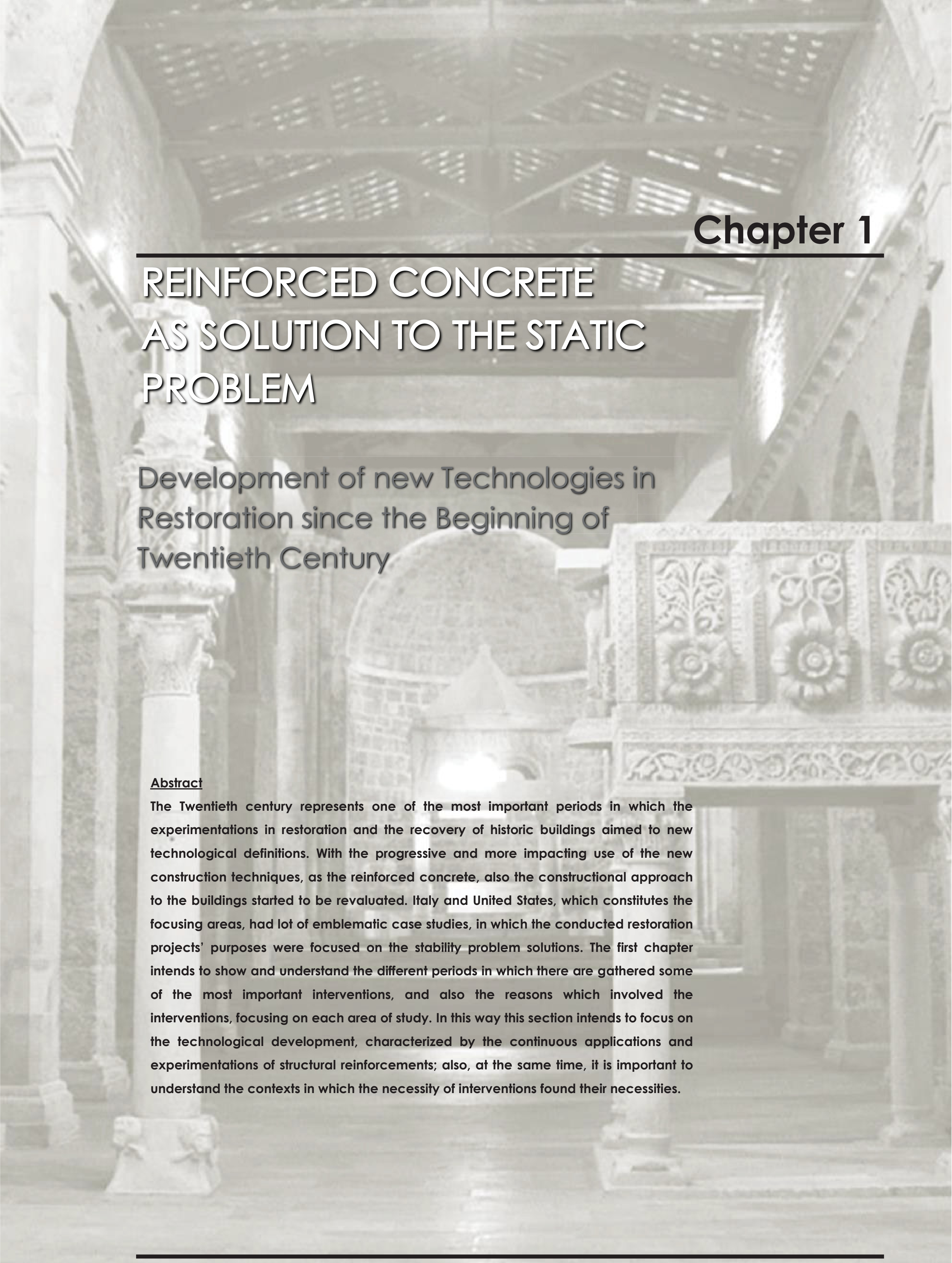
d) Individuazione tipologie di intervento e primi raggruppamenti. Dopo la redazione di schede sintetiche di analisi, tutti gli interventi analizzati sono stati raggruppati a seconda delle tipologie, in maniera tale da individuare i primi caratteri comuni tra le aree e a seconda dei periodi di intervento.

e) Approfondimento di alcuni casi di studio. Alcuni degli interventi selezionati vengono studiati in maniera più dettagliata, con ulteriori indagini di archivio e bibliografiche, in maniera tale da avere un quadro conoscitivo più approfondito. Anche in questo caso, l'analisi è stata incentrata su entrambe le aree di studio, cercando di confrontare e trarre punti in comune tra i contesti culturali e le strategie di restauro.

f) Considerazioni su forma e struttura. Grazie agli approfondimenti della fase precedente, è stato possibile porre le prime valutazioni sugli interventi esaminati, approfondendo i caratteri e le problematiche relative al rapporto tra forma e struttura, venutosi ad alterare nello specifico con l'inserimento delle nuove strutture in calcestruzzo armato.

g) Valutazioni critiche. Sulla base delle considerazioni sul rapporto e struttura, la fase finale del lavoro intende soffermarsi sulle problematiche riscontrate nei periodi successivi agli interventi realizzati, valutandone l'impatto strutturale e formale anche in conseguenza dei nuovi eventi cui gli edifici restaurati sono stati soggetti. In questa fase, vengono anche esposte i possibili sviluppi futuri della ricerca.

Il lavoro di tesi, pertanto, è stato posto in accordo alle fasi della ricerca, cercando di mantenere un continuo parallelismo nello studio delle due diverse aree tematiche. Dopo una breve introduzione riguardo gli sviluppi tecnologici del nuovo materiale dalla fine del XIX secolo e la sua immediata applicazione nei campi della costruzione, sia nelle nuove edificazioni che nel risanamento strutturale di edifici esistenti, viene posta l'attenzione su alcuni dei fattori che hanno favorito l'utilizzo degli elementi in calcestruzzo armato nei beni monumentali nei primi anni del Novecento (Capitolo 1). Con le prime sperimentazioni, si accresce il dibattito internazionale sui nuovi materiali nel restauro, da cui vengono tratte le prime indicazioni applicative e le teorie internazionali, cui fanno seguito le normative nazionali (Capitolo 2). L'analisi di casi campione, in accordo ai differenti periodi storici, svolta per ciascuna delle aree di studio, intende fornire una conoscenza generale del panorama, in cui vengono identificati casi emblematici, da cui è possibile trarre opportuni confronti e parallelismi (Capitoli 3 e 4). L'impatto dei restauri, nel rapporto tra forma e struttura, viene approfondito con il caso campione della Basilica di Santa Maria di Collemaggio a L'Aquila, restaurata a più riprese nel corso del XX secolo, con interventi realizzati in calcestruzzo armato, e soggetta al recente terremoto del 6 aprile 2009, grazie a cui è stato possibile valutare alcuni comportamenti e danneggiamenti dovuti alla modifica dell'apparecchiatura costruttiva (Capitolo 5). Infine, sono state tratte alcune considerazioni critiche, in base alle tipologie di restauro riscontrate in rapporto ai diversi periodi storici categorizzati, e ai possibili ulteriori sviluppi di ricerca (Conclusioni). In appendice, vengono riportate le schedature relative a ciascuno degli interventi di restauro analizzati, divise per aree tematiche (centro Italia e sud degli Stati Uniti) e al cui interno sono presenti delle tabelle riepilogative su tipologie, ragioni e periodo.



Chapter 1

REINFORCED CONCRETE AS SOLUTION TO THE STATIC PROBLEM

Development of new Technologies in Restoration since the Beginning of Twentieth Century

Abstract

The Twentieth century represents one of the most important periods in which the experimentations in restoration and the recovery of historic buildings aimed to new technological definitions. With the progressive and more impacting use of the new construction techniques, as the reinforced concrete, also the constructional approach to the buildings started to be revaluated. Italy and United States, which constitutes the focusing areas, had lot of emblematic case studies, in which the conducted restoration projects' purposes were focused on the stability problem solutions. The first chapter intends to show and understand the different periods in which there are gathered some of the most important interventions, and also the reasons which involved the interventions, focusing on each area of study. In this way this section intends to focus on the technological development, characterized by the continuous applications and experimentations of structural reinforcements; also, at the same time, it is important to understand the contexts in which the necessity of interventions found their necessities.

Interior of the Basilica of San Clemente a Casauria, Castiglione a Casauria, Italy

Capitolo 1

IL CEMENTO ARMATO COME SOLUZIONE AL PROBLEMA STATICO

Sviluppo delle nuove tecnologie nel restauro dall'inizio del Ventesimo secolo

Abstract

Il Ventesimo secolo rappresenta un periodo in cui la sperimentazione nel restauro e recupero dell'architettura storica ambisce a nuove definizioni tecnologiche, con l'inserimento progressivo e sempre più esteso delle nuove tecniche costruttive e di recupero, quali l'utilizzo del calcestruzzo armato, tali da rivalutare anche la logica alla base dell'approccio costruttivo al restauro. Le aree di studio, Italia e Stati Uniti, si caratterizzano per la presenza di interessanti sperimentazioni, emblematiche del nuovo corso. Focalizzando lo studio sulle aree di ricerca, il primo capitolo intende individuare e analizzare le stagioni di restauro più significative, suddivise a seconda delle vicende storiche che, generalmente, hanno interessato le aree di studio. cercando di contestualizzarne non solo l'evoluzione tecnologica, sempre più consolidata andando avanti negli anni, ma cercando anche di comprendere i diversi fattori che hanno favorito gli interventi riparativi. Suddiviso quindi in due sezioni, il capitolo approfondisce specificatamente questi due differenti aspetti.

Introduction

"Reinforced concrete structures solve static problems in earthquake zone buildings. Seismic activity has caused enormous damages to Italian monuments, and the buildings have been damaged further by detrimental restoration works performed by poorly trained designers and technicians; now the buildings are able to reclaim their beauty and life, safe from irreparable damages. Deliberate and careful conservation is both social and economic work."[1]

With these words, Ignazio Carlo Gavini[2], one of the most prominent officers in Soprintendenza Monumenti e Gallerie dell'Aquila, the control authority for cultural property in Abruzzo and Molise, in 1923 defined the strategic and technological importance of using reinforced concrete in the restoration of monumental buildings. These words show the state of the development of new technologies in the construction field, on one side, associated also to the necessity of preservation and recovery of historic architectures, left in severe risk to collapse.

After the theories of Ruskin and Viollet Le Duc, which characterized the first phases in the restoration development, the twentieth century represented the period in which the theory of restoration had been developed considerably, overtaking the debates of the previous periods and trying to identify the correct ways in the approach to the historic heritage. The presence of Camillo Boito and Gustavo Giovannoni in the Italian context, which influenced the worldwide debate, had been primary in this way.

The use of reinforced concrete systems in restoration works found in the beginning of the Twentieth Century the starting point period, thanks especially to the two different main aspects that involved and spread its use all around the world, as the wars and the natural destroying events. The century represented also the most intensive period of experimentations about the possibility of the new materials, which uses had been improved in particular in the second postwar, thanks also to its facility of use and short time of work. The development and the experimentations found also the key point of its salability in the pursued attempts of the most important architectural and structural designers of that time.

"Reinforced concrete is the most beautiful building system which the human race found until today. The possibility to create molten stones, of all forms, stronger than the naturals because able of resist to traction stresses, has something of magic inside. With this way, the fantasy in construction fields spread without any limit, even if it is not so pleasant to verify how nowadays

all these possibilities have not been so explored and used."[3]

The cultural context is influenced by avant-garde theories of the period: the key point of using new technologies such as reinforced concrete in restoration works is the Athens Charter for the Restoration of Historic Monuments, released in 1931, in which the new technologies, in particular reinforced concrete, started to be allowed in the restoration[4]. Indeed, before its release there had been realized some recovery and restoration works in which the experimentation of the new materials had been already launched, but after the release of document, the works of restoration found in the use of reinforced concrete the key point of the structural improving and of the redefinitions of elements, where collapsed. Among the areas of study, lot of the pursued works explained the importance of the document, showing how the document took so much importance regarding the use of new technologies, thanks also to the historic periods of applications [5]: the thirty and forty years presented an overview characterized by the destruction by the world wars and the damages involved by the natural phenomena, promoting the necessities and the urgency of reconstructions. The second postwar, with the economic funds made available among the national governments and the release of the new rules and theories in the restoration field, launched one of the most intense campaign of restoration, in which the use of new materials became the starting point of the structural recovery [6]. The use of reinforced concrete can be analyzed and studied not only as a solution to the static problem, but also as the development of technologies and their development in their use in the restoration fields.

At the beginning, the spread and the launch of the modern material and its applications was not due to the same reasons all over the world. Instead, its uses found diversities in the theoretical and economical specific contexts. While in Italy the theorizations and the patents relatively to its use were fundamental for the first applications, in the American area its spread is related to the economical presence of the cement companies [7], which from the end of the 19th century improved their activity and production: their presence can be considered influencing in lot of important works, as in the restorations in the interested area.

Structure of the Chapter

This first chapter of the dissertation intends to analyze different aspects of the research, trying to identify the subject of the work, according to the periods, typologies and reasons of restoration. In particular, this part can be considered primes of the entire work, as it introduces the case studies and the related problems connected to the necessities of preservation, which also today still represent "a problem to be solved".

The following paragraphs analyze the different aspects related to the research, such as the area of study and the period of restorations. The first part intends not only to introduce and describe the different areas in which the research had been conducted [8], but also to individuate and represent particular areas, physically completely independent from each other, but which present interesting aspects in common. In the first subparagraph there are defined not only the geographical areas of the research, but also the typologies of the studied buildings, referred to each area of interest, and also the most important event which characterized the nature and the architectures of the places. Instead of the first section, the second subparagraph focuses on and individuates the different periods of restoration taken as references for the research, from the beginning to the last decades of the 20th century, trying also to recognize specific periods in which the activity of restoration had been pursued continually. This last part intends also to introduce some of the characteristics of the interventions, trying to identify the common aspects among the studied areas. In particular, the aim of the chapter, with the two different subsection, constitutes in the introduction of the problems, related to each areas of study, with also the descriptions of the human and artificial factors which involved the studied works, and in a brief description of the different campaigns of works during the century.

notes

[1] Gavini, 1923

[2] Ignazio Gavini had been one of the most important supporter of the reinforced concrete's application in the restoration field (Cf. CHAPTER 2, Paragraph 2.1 "Before the rules").

[3] Nervi, 1945.

[4] The Athens' Charter for the Restoration of Historic Monuments represented the turning point in the restoration of monuments, according also to the use of new materials (Cf. CHAPTER 2, Paragraph 2.2 "Theories and Rules")

[5] The necessities which involved the release of the Charter must be found in the damages inducted by a series of event, such as the abandonments, the natural disasters, the new sensitivity to the old structures caused of the Romantic view of the ruins; the reconstructions of the historic architectures became also the recovery activity of the identity of the societies.

[6] In the specific chapter, the structural improving on the buildings inducted by the restoration works of the three analyzed periods will be analyzed according to the present day, taking as reference the damages involved by the more recent natural disasters.

[7] With the different reports provided by the national government, it is clear how the new materials were diffused in every area of the United States already from the end of the 19th century (Eckel, 1913).

[8] In particular, the interested area of the study (Central Italy and Southern Part of United States), had been analyzed directly. In particular, the research conducted in the American context had been also realized with the collaboration of the University of Texas at San Antonio (UTSA)

1_1

THE AREAS OF STUDY

Case studies of the research between Italy and United States

The research had been conducted among different areas, aiming to identify the common aspects and to compare the different pursued approaching methods during times. According to the strategy and the interested period these preliminary studies can involve different comparisons among the case studies, in a way to underline and show the main important characteristics of the restoration approaches in the interventions which occurred in all the studied areas.

According to the main topic, reinforced concrete started to have an important role as a solution to the precarious state of damaged buildings, in particular in some areas which presented the necessity of structural recovery due to lack of resistance. One of the aspects related to the necessity of structural recovery finds its origin in the natural context; as an example, natural events able to involve damages to buildings can be considered the earthquakes. According to this reason, and also thanks to the possibility to analyze and study directly some of the interested areas, the research had been focused on areas characterized by the presence of strong earthquake possibility, such as specific areas in Italy and United States[9]. The seismic stresses released during the quake events induced different behaviors which, in case of masonry buildings, with irregular form and materials, are not able to resist to them, going next to have several damages or, in some situations, to collapse.[10]

Areas of the study

The interested areas, in some of which the research had been conducted directly on the territory, are the central part of Italy and the southern part of United States, focusing in particular on Texas and California. In particular, the analysis of the restoration had been also focused on few typologies of historic buildings, which had been identified for each area, thanks also to the historic documents and available bibliography; according to this turning point, the aim of the work is focused on the historic architectures of the exposed areas, such as the civil and religious monumental building of Italy, as churches, *conventos* and defensive architectures, and the Franciscan Missions of United States, taking in reference in detail the churches which had been founded since the beginning of the missions.

Central Italy: architectures and events

The first area on which it is necessary to focus on is the central part of Italy. With the presence of lot of historic architectures, the area presents lot of interesting interventions with reinforced concrete structural addition to the existing buildings. The interested territory, with its complex morphology and historical stratifications, is also exposed to one of the most dangerous natural phenomena which can involve diffuse damages to the structures, such as the earthquakes[11].

According to this risk, and also to the realization of some preservation interventions with reinforced concrete, it is useful to analyze the central part comprised among Abruzzo, Lazio, Umbria and Marche, typical for the dangerous earthquake that can occur. This territory had in the last century lot of destroying events, which, someone more than the others, radically caused the necessity of restorations.

The study intends to analyze some case studies in particular in Abruzzo's hinterland. Characterized by the complex and uneven geographical and morphological structure, the region is typical also for the renowned quake events. These natural phenomena characterized the area in the past and present history, thanks to their strong intensity which caused substantial modifications in the aspect and architectures of the places. In particular, the province of L'Aquila in the last hundred years, had been strongly influenced and damaged from the seismic activity. Abruzzo's region, as the entire central part of Italy, is strongly connected to the risks due to the morphological aspects of the underground. In particular, the earthquakes represent the most dangerous risk of the area, with also a series of destroying events which occurred during the last centuries. The last one in particular had been interested by three different events which in large part modified the entire territory with the spread damages[12].

The event of January 13th 1915 [13] completely destroyed the entire city of Avezzano, causing also lot of damages and collapses in the places next to the Fucino plane [14] and interesting the close city of L'Aquila [15]. With the spread and several damages to the entire territory, the event showed the high level of vulnerability of the construction heritage in comparison to the stronger quakes and the necessity of intervention.

Another quake event which radically influenced the necessity of making safe the historic heritage was the event of Maiella in September 26th 1933 [16]; weaker than the previous event, with 5.7 degrees of intensity in Richter scale, the event interested 65 different municipality areas in Abruzzo, among the provinces of L'Aquila, Chieti and Pescara, causing different and several damages in thousands of buildings and, sometimes, also some collapses.

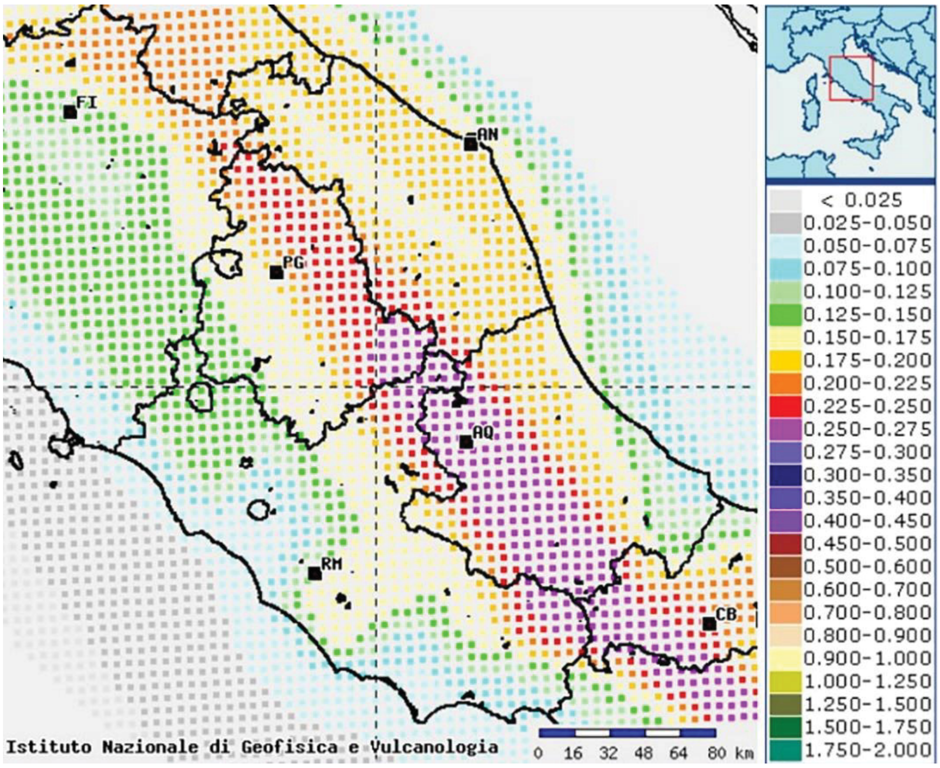


Fig. 1.1
Map of seismic risk of Central Italy, expressed in terms of ground peck acceleration, probability of excess of 10% in fifty years. (INGV)

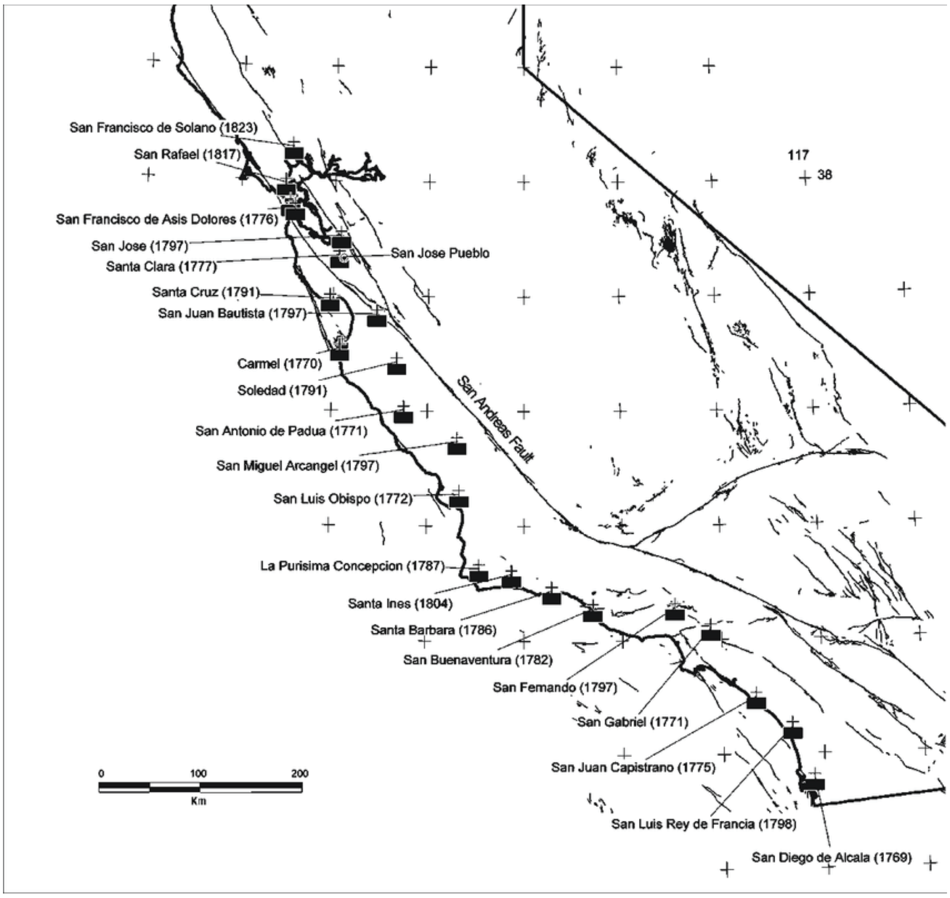


Fig. 1.2
Map of the Franciscan Mission of California in comparison to the San Andreas' Fault. (Toppozada, 2004)

In central Italy, the research intends to analyze also other contexts and regions, such as Lazio, Umbria and Marche, trying to focus on the specific areas characterized by interventions of structural recovery on historic buildings. Also in these area, the natural impact involved by the destroying events has a primary role. Lazio's region, in particular the areas next Abruzzo, suffered of the same earthquake events, in detail the ones of 1915, which involved several damages also to the local architectures

Instead of the next areas close to the earthquake of Marsica, which suffered and presented damages to the structures, such as the province of Rieti and the neighborhood areas of Fucino's plane, the other places of interest, as the remaining territories of Lazio, and Marche and Umbria regions, were interested by destroying events in the recent past, with strong earthquakes since the Seventy years [17]. The interior areas of Lazio had been interested by a strong event in February 6th 1971 which interested in particular the Tuscania area, causing damages to the historic buildings, which inducted restoration works in the seventy years by the Soprintendenza, with the insertion of reinforced concrete elements. As well Lazio, Marche and Umbria were interested by strong events in 1972, with two different occurrences [18] which produced lot of damages to the historic buildings.

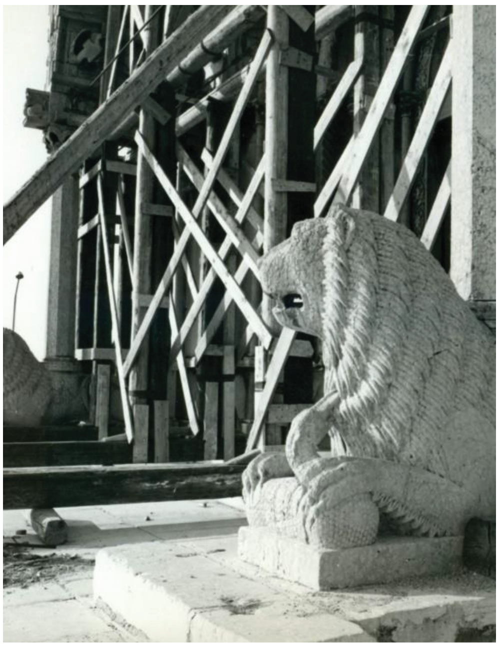


Fig. 1.3 - left
Church of Santa Maria Maggiore in Tuscania after the earthquake of 1971 (A_4|9).

Fig. 1.4 – right
Church of San Ciriaco, detail of the main gate after the earthquakes of 1952 (A_2|3).

In 1984, on April 29th an intense earthquake struck in the area included among Gubbio, Perugia and Assisi, in Umbria, causing a large number of damaged buildings [19]. In the same year, in May 7th, another quake, whose epicenter had been in San Donato Val di Comino, in Frosinone's province, Lazio, caused a large number of damages in the neighbor areas, as Abruzzo (large part of the interested area was the Marsica again), interior areas of Lazio and Campania, causing damages also in Sulmona.

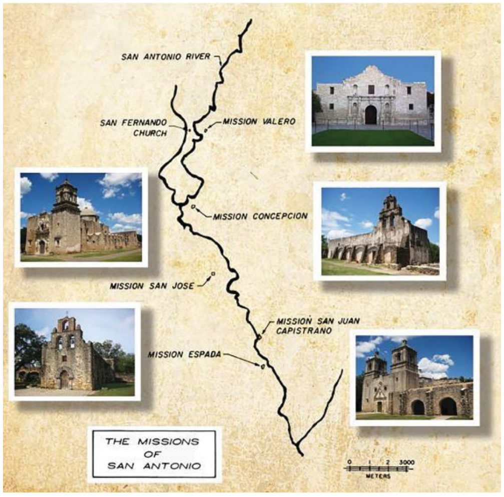
In addition to these main events [20], other local earthquakes [21] occurred in the analyzed area, interesting limited territories, involving other restoration interventions: the events of September 5th 1950 and August 8th 1951, so called the earthquakes of Gran Sasso [22], which hit the area among the cities of L'Aquila, Teramo and Campotosto; the event of September 1st 1951, which hit the area among the provinces of Ascoli and Macerata, with few damages also in the provinces of Perugia and Teramo; in September 19th 1979, another event hit this area, with the epicenter in Norcia.

Beyond the natural disasters, some of the historic architectures were interested also by collapses and damages due to the abandonment and the shortage of preservation works.

Southern areas of US: architectures and events

The other area of the study is the southern part of United States. Focusing in particular on Texas and California, the interested space represents one of the most compelling case studies of preservation of historic buildings. The main efforts of preservation had been applied in particular on the Franciscan Missions, which were systems of buildings founded by the Franciscan friars at the end of 18th century.

The Christianization of the Western Hemisphere constitutes one of the most significant movements of the past five centuries. As a religious force that became dominant within a short time over a massive land rea, the movement has had no equal in history.



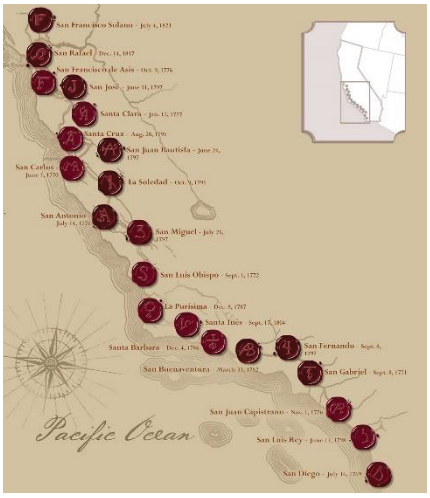


Fig. 1.5 - left
The Franciscan Missions in San Antonio Texas (2019).

Fig. 1.6 – right
El Camino Real: the 21 Franciscan missions in Alta California (Sewall, 2013).

Although their major objective was to spread Christianity among the natives, the missions also served as a force for spreading Spanish culture and political control. Essentially, they strove to change the nomadic Native America into a copy of an urbanized Spaniard. The mission tended to be located newer concentrations of the Native American population. A mission did not simply consist of a single church, but instead it was a complex of buildings that housed a whole community. The major element was a group of buildings arranged around a quadrangle: the church was usually the largest of the buildings, commonly occupying a major portion of one side of the quadrangle. Frequently, the church portion of the mission complex underwent several rebuildings, becoming larger and more imposing with each building campaign. Other sides of the quadrangle included the living quarters, offices, dormitories, workrooms, kitchen and storerooms. The construction materials consisted of adobe clay, timber and occasionally stone.

Initially, Texas was not viewed as a likely area for missionary activity. But in the late seventeenth century, fears of French settlement prompted the Spanish to send soldiers and missionaries into east Texas. On the absence of an actual French treat, the posts and missions were disbanded. By the second decade of the eighteenth century, however, the French threat again emerged. The Spanish sent out another party to Texas this time to the area now known as San Antonio, in which still today there are five of the most important Spanish missions in United States. Founded from the 1718, with the creation of San Antonio De Valero Missions, renown today as the Alamo, the Franciscan missions in San Antonio increased radically in the following decades, with the creation of other four missions to the south of the city, forming the "Mission Road" of San Antonio.

The Spanish missions of California represent the state's oldest and richest historical legacy of the area. Their story and development has been told by the Franciscan missionaries themselves and followed a century later by H. H. Bancrosfts' histories at the end of 19th century. Founded in the period between the end of 18th and beginning of the 19th centuries, the 21 Californian missions constitute "El Camino Real", "The Royal Road", a 600 miles road along the Alta California. Because also the position of these architectures is next to the San Andreas Fault, which is world-famous as the epicenter for destructive earthquakes, most of the restoration works occurred after quake events [23].

The deterioration of the missions accelerated following California statehood in 1850, when the crumbling adobe edifices were disdained by the new American arrivals as relic of a bygone civilization. By the end of the century, most of these once-vast establishments gad all but melted back to their native soils. During these years of abandonment and neglect, however, a number of mission churches were maintained and continued to serve their local populations. Many became repositories not only of religious and secular art but also of the cultural and religious heritage of the state's almost-forgotten past. And, by the 1870s, missions and mission ruins were increasingly attracting the attention of painters and photographers such Henry Chapman and Ford and Carleton Watkins [24]. This in turn stimulated the growth of the missions preservation movement, which by the early years of the twentieth century was well under way [25].

The conservation of existing architecture also in these areas argues with the morphology and the geological and climate characteristics of the areas. In the US case studies, earthquake maintain, as in central Italy, their role for risk situations and damages. This is in particular typical of the historic architectures of California; in this part of America, the territory is strongly influenced by the presence of natural destroying phenomena which involved several damages to this kind of buildings.

In particular, all the entire peninsula of California is interested by the presence of San Andreas' Fault, from which strong quakes are generated; in this way, all the monumental buildings, as the Franciscan missions, find in this event the risk of damage. The American areas are also related to the importance and impact of destroying natural events: earthquakes, which are the main problem related to the geography of California, keeping in mind some destroying events originated from the San Andreas' Fault, are not only the natural phenomena able to involve damages to historic buildings. Texas, for example, is not considered a dangerous place according to the seismic activity of the subsoil, but it is characterized by the presence of other natural events, as hurricanes and floods, which involve damages to buildings too.

Some of the most destroying events which interested the Californian missions happened at the beginning of the last century and entailed the analyzed restoration interventions [26]. At the beginning of the century, in 1906 had been interested by the strong earthquake of San Francisco in April 18th 1906, which caused more than 3000 victims and several damages and collapses in large part

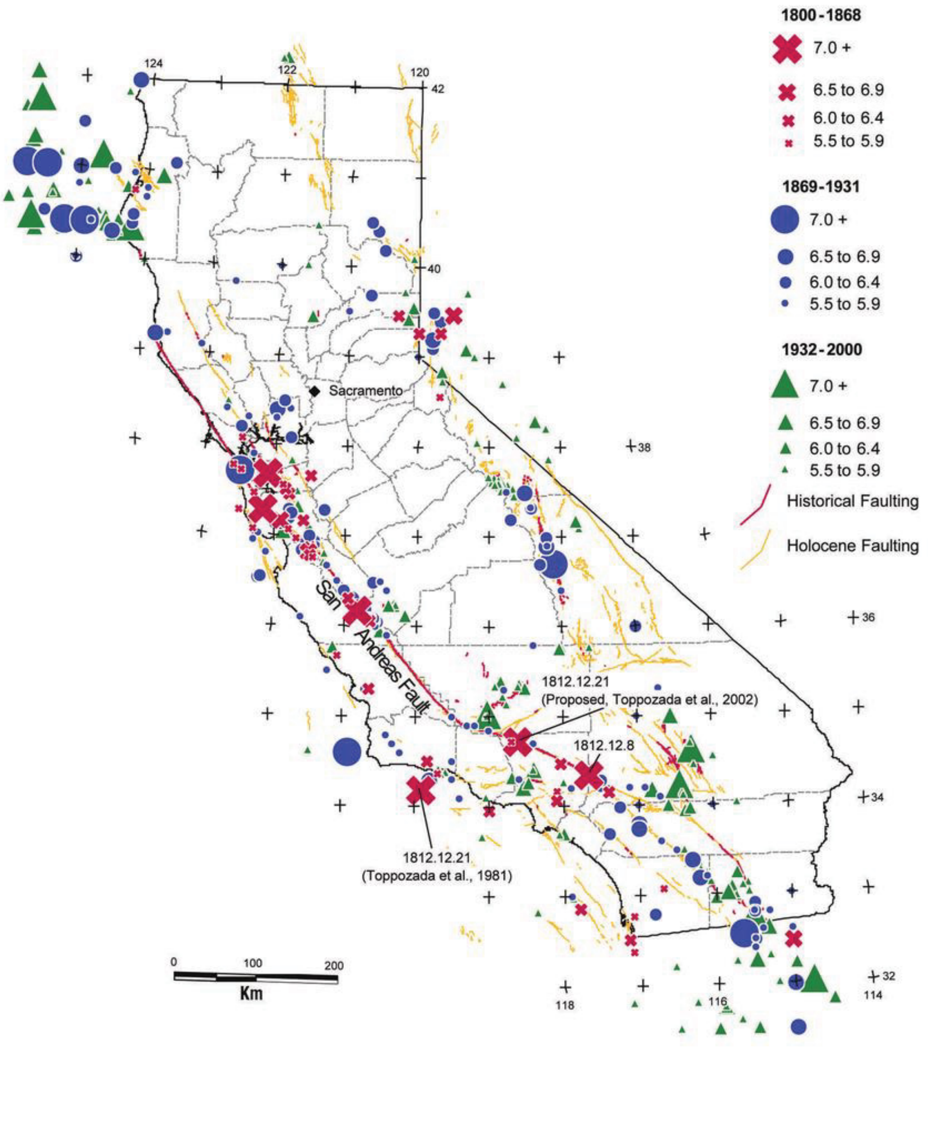


Fig. 1.7
Historical Map of the strongest earthquake (from Mg. 5.5 Richter) which interested California since the 19th century (Toppozada, 2004).

of the territory; in this case, lot of historic buildings, in particular some of the Franciscan missions had serious damages and collapses. Few years later, the event of Santa Barbara, which occurred in June 29th 1925 [27], caused damages to the local territory, with collapses of buildings and damages to the missions [28].

As opposed to the Californian missions, the Texas missions in San Antonio have not been subject to quake events [29]. Instead, hurricanes and violent rains characterize the damage to the missions, due to climatic forces like hurricanes, which derive from the Gulf of Mexico. The city of San Antonio had been interested several times at the beginning of the twentieth century by flooding and hurricanes which provoked damages and collapses to the historic buildings, as the missions, whose decay had been started since the secularization and the abandonment.

According this point of view, Texas and California can be considered as case studies as well as they present some restoration interventions during the last century with the same approaches to the buildings and the use of modern technologies. The interventions analyzed in this chapter were carried out in the period between the 1930s and the 1950s.

Some common aspects among the areas

With the analysis of the interested areas, the "natural destroying" aspect, which emerges during the description of each area, represents the turning point of the research, causing the necessities of restoration, which interest the entire century. Other common aspects can be referred to the typologies of building: in lot of cases, the missions founded in the American context present common characteristics with the European approach to the construction, due also to the education of the Franciscan friars, which tried to reproduce the same buildings the saw in their place of origin.

The necessity of reconstruction in safer conditions in comparable period – as the earthquakes which occurred in Marsica and California, and also the hurricanes and flooding which interested San Antonio - involved the beginning of experimentations of new materials, considered as progressive solutions to the static problems, in comparable period. Also, both areas represented the field of experimentation and reinforced concrete applications on historical buildings, without any differences according to the nature and forms of the existing structures, with same applications indifferently from the typologies and geometries of the masonries. This aspect will be also explained in the following paragraph.

notes

[9] Both areas are characterized by the happening of strong earthquakes in the last century and in the recent past.

[10] With the occurrence of an earthquake, a hybrid structural systems can show different typologies of behavior, due also to the regular or irregular form.

[11] In this case is also recommended to refer to the following section of the chapter and, also, to the next chapters which focuses on the interested areas of interventions.

[12] It could be interesting to analyze also the state of the building before the quake events of the 20th century, thanks to the historical research and the description of the monuments, as for example the Abbate's book (see bibliography). Thanks to this sources it is possible to understand the damaged involved by the quakes and, in particular, the modifications with the restoration interventions.

[13] Castanetto, Galadini, 1999; Serafini, 2008; Donatelli, 2010.

[14] Munoz, 1915.

[15] Also, there were recorded damages in the neighborhood regions of Lazio and Marche (from Papini, 1915).

[16] Donatelli, 2010.

[17] Other quake events occurred in the interested areas also before the Seventies, but there were not found any information about the insertion of reinforced concrete elements during the restoration works, except the interventions of Benincasa Palace in Ancona (code A2 |1) and the Cathedral of Santa Maria Assunta in Fermo (code A2|2). For example, an important event occurred in October 30th 1930, causing several damages among the areas of Pesaro and Ancona.

[18] Both events occurred in Ancona, respectively in January 25th and June 14th, causing several damages to the structures

[19] About 10.000 damaged buildings, 243 of which were evaluated unrepairable.

[20] In this list it is not considered the event of September 26th 1997, which interested a large area in Umbria and Marche, with several damages, collapses and victims.

[21] With less intensity of the main events of the century, but which are also reported in the synthesis forms of interventions.

[22] Which is the name of the mountain which separates the area of L'Aquila and Teramo in Abruzzo.

[23] The geographical distribution of the missions in California ranges from San Diego on the south to San Francisco Solano on the north, taking in about two-thirds of the length of the state. (from Newcomb, R., 1914)

[24] Also, in the following decades, the publication of the novel "Ramona" by Helen Hunt Jackson increased the "myth of the missions" and gained widespread popularity among the California's new American inhabitants

[25] Gradually, the romantic narrative of the missions' myth has been supplemented with a wide range of other perspectives, and today the mission legacy is a matter of considerable debate (Kimbro, 2009)

[26] The list of events is referred to the successive restoration and structural recovery interventions in which it is certified the use of reinforced concrete as the structural improving solution

[27] Corbett et al., 1982

[28] The impact of these events on the historical monumental architectures brought a high level of damages. The damaged mission of Santa Barbara, the main building of the area, also according to its importance in the definition of the identity, and also being interest by a restoration intervention with the insertion of reinforced concrete systems, will be specifically analyzed.

[29] There are reported also some earthquake events, which find their origin in the gas and petrol extraction from the underground. The earthquake with this origin have a different propagation in the territory, with momentary vibrations, instead the "normal" quake events.

1_2

THE PERIODS, THE REASONS OF THE RESTORATIONS AND THE USE OF REINFORCED CONCRETE

Most important phases of restoration in the last century

This section intends to expose and define the main important phases of restoration interventions of the last century, in which it is possible to individuate the most interesting works, according to the methodology and the approach to the existing building. Part of the paragraph aims also to show the main reasons which involved the interventions, in a way to find the links among the periods and the reasons.

RC's development

Primary, it is necessary also to understand the development of the reinforced concrete production during times, related to the possibility of commerce and the spread of its use. In the previous paragraph, there have been introduced the initial correlations among the areas of the study, individuating in particular some periods characterized by the happening of destroying events, such as earthquakes, floods and wars. According to these reasons, some of the restoration campaigns pursued during the last century had been conducted in the same reference period, independently from the areas. Also, it could be remarkable how the same period of restoration which occurred after the destroying events can be considered rich of experimentations with the new materials as well as in both contexts. As the difficulties involved by the natural disasters, other aspects in common among the areas can represented by the release of the Athens' Charter for the Restoration of Monuments[30] in 1931, which gave the start to the new campaign of restorations, together with the coming of the two world wars, which stopped the economic funds made available for the different reconstructions.

Phases of restorations

In this way, and according to the conducted analysis among Central Italy and United States, after a starting phase of experimentations, it is possible to identify three different periods: there is an initial phase, so called "phase 0", in which there are the first experimentations with the new materials in the various attempts of structural recovery; then, the other periods are referred from the end of world war I to the entire Twenty Years, till the release of the Athens' Charter (phase 1), then the period before the world war II according to the instructions of the international theories, (phase 2), and lastly the second post war (since the Sixties to the Seventies, phase 3), characterized by the new economic deals and the new availability of funds in restorations.

With the individuation of different historic periods in which the restoration activity had been pursued continually, it is interesting also to underline the reasons and the main events which involved the widespread necessity of recovery of historic architectures.

Phase 0

The "phase 0" had been introduced differently from the others, because it comprises the first experimentations in reinforced concrete before the happening of the main important natural disasters, already introduced above. With the first applications in the field of new constructions, reinforced concrete started to be also experimented as a "static solver". This is the period in which, after the invention and license by Hennebique [31] of reinforced concrete, which certified the creation of the new material in 1892, reinforced concrete started to be used in Italy. The patent of the "Hennebique System" had been introduced in 1894 in Turin by the engineer Giovanni Antonio Porcheddu, which improved the existing system with the bend of steel bars, thanks also to the agreement among the Studio of Engineers Ferrero & Porcheddu and the engineer Giovanni Narci, head of the Italian Agency of Maison Hennebique. Thanks to the excellent results, the company Porcheddu became the exclusive licensed company in Italy for reinforced concrete applications, operating first in Turin's areas and neighborhood, then in the entire national territory. In this time there are realized some of the most interesting precursor restorations in the central area of Italy: one of these interventions is the Loggia dei Papi in Viterbo [32] (A_4|1), restored in 1902-1904, and characterized by the use of reinforced concrete solutions for the recovery of the old aspect. The project can be considered precursor by the presence of reinforced concrete beams, solving the static problem related to the aim of reopening the original empty spaces of the loggiato, closed caused of structural risks. Also in this phase, the restoration theory started to be renovated by the experimentations and the theorizing of important Italian figures, such as Boito and Giovannoni [33].

The study of phase 0 is primary important to understand the development of the new materials after the first patents and the first uses in restoration works. In this way, it is easy to understand how after the natural disasters, which interested both areas of study, involved the use of these new techniques. The monumental built heritage represents also the identity of specific societies and ages; destroying events, as the ones which occurred from this period to the last years of this research, can remove these links and let all these identities lost in the memories. The application of reinforced concrete, not only as a static solver, but also as an "instant mean" represented one of the possible solution avoiding the loss of the specific identities, hurt by the natural and human disasters.

Phase 1

Phase 1 is strongly linked to the necessities of reconstruction and recovery due to the natural disasters, such as the earthquakes of Marsica and San Francisco. The works conducted in this period represent the first real attempt worldwide in recovery and restoring historic building with the auxiliary from new technologies. Indeed, while in the central area of Italy the experimentations on historic buildings were already tested in lot of works, in California the use of reinforced concrete on historic buildings represented an innovation, due to the lack of previous theorizations and codes[34].

One of the first events in which the buildings' recovery started to be linked to the social identity recovery of local territories is the earthquake of Marsica, occurred in January 13th 1915, which destroyed the entire city of Avezzano, in L'Aquila province, causing several damages and a large number of victims in the neighborhood [35]. The strong quake interested all the constructions, in particular the monumental buildings, which, with their irregular form and structures [36], presented weak resistance to the seismic stresses and went damaged or collapsed. In this arc time it is important to remark that Italy suffered other strong quake events at the beginning of the Twentieth Century. The event of Messina-Reggio, occurred in December 28th 1908 hit and destroyed lot of the built heritage, causing a huge number of victims and spread damages also in the ordinary buildings [37], after which there were applied the first national measures for constructions[38]. In Marsica, the necessity of reconstruction and restoration of the hit areas is strongly connected to the first funds available to the reconstructions; in this period there are certified the first wok in which reinforced concrete started to be used in the renovation and recovery of buildings, both historical and monumental and also ordinary. Some of the works of recovery had been started immediately after the quake event, trying to recover and maintain also the symbols and the identity of the places hit by the quake. The other interventions started only after the end of world war I, continuing the works stopped before. During this period, the Soprintendenza, the control authority of territory's heritage, employed a primary role in the restorations and recoveries of the historic buildings, continuing the experimentations in reinforced concrete started before the wars. There are some buildings which can be defined emblematic, thanks to the insertion of auxiliary structures in reinforced concrete, as the Basilicas of Collemaggio in L'Aquila and the one of San Clemente a Casauria, whose restorations comprised the period around the Twenty years, and which will be analyzed in the specific chapter.

In parallel, also the American context [39], interested by the strong earthquake of San Francisco occurred in 1906, presented the necessity of reconstruction in large part of the interested area. Also, the Franciscan missions of California were already interested by intentions of restoration and recovery, thanks to their romantic aspect of ruins caught by the photographers and the novels, and increased in the first efforts of preservation, inducted by the association of engineers [40]. The Civilian Conservation Corps [41], started to analyze and study the ruined missions, aiming to find the necessary funds for the restorations. With the earthquake which hit the California, with the first funds made available the restoration started. The interested period comprised also the Twenty years, which in this context presented other destroying events, which involved the necessities of recovering in more cases. In this period, lot if important buildings were restored with the use of modern technologies, in consequence of destroying events, both in Texas – with the hurricanes and floods which interested the area of San Antonio, with the collapses of roof in some historic buildings – than in California – with the other earthquake of Santa Barbara occurred in 1925, which involved damages to the historic mission founded by the Franciscan friars and also to the neighborhood, obliging and involving the necessity of reconstruction and recovery which started only years later.

Lot of restoration occurred in this period can be considered, as well as the Italian case studies, precursor of the new theories: the restoration works pursued in the Alamo, the old mission of San Antonio de Valero in Texas (B_1|1), and the interventions in the missions of San Juan (B_2|1) or Santa Barbara (B_2|2) in California expressed the necessity of a general “update” of the restoration theory.

The turning point of the international debate had been the Athens’ Charter for the Restoration of Monuments, which kicked off the new campaign of restorations, since the 1931. The document had a primary role in both areas, thanks to the new approaches to the buildings and the “permission” in the use of modern technologies. While in the American context, lot of the analyzed restoration interventions were concluded during this period, in Italy lot of the analyzed buildings will be concluded in the third phase of the research.

Phase 2

During this phase, the situations among the different areas of study is different. In particular, in the American context, lot of the restoration works finds in the New Deal by the president Roosevelt [42] the necessary funds for the works. This period is characterized by a numerous series of restoration interventions both in California than in Texas, which interested large part of the remaining unrestored missions, till the Forty years. Lot of funds were available with federal programs, which improved the existing efforts as the CCC, with the creation of other associations as HABS [43], Historic American Building Survey - which interested in the renovation of historic buildings, with also a deepened study and survey campaigns on the missions and the proposal, in some cases, of the recovery projects - and the National Park Services. In California, in 1934 the architect Philipp Primm became one the most important precursor for the restoration campaign of the Californian Missions [44], thanks also to the work of the Civilian Conservation Corps, which in this period found the brightest period since their foundation. In San Antonio, some of the most important restoration interventions were concluded in this phase – one example is the restoration of the Missions of San José (B_1|3). Also in California, the attempts of recovery of the damaged missions – caused by the earthquakes and the abandonment, due to the secularization and the progressive decay of the structures – were completed thanks the insertion of reinforced concrete structures.

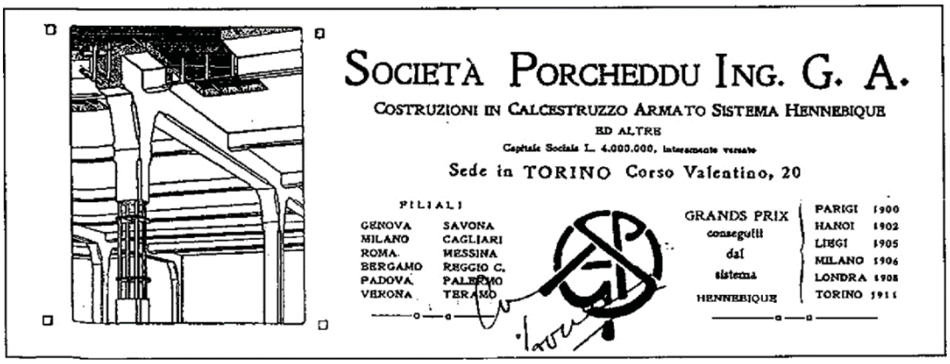


Fig. 1.8
Characteristics of the "Hennebique system" structures in a logo for postal envelopes of the Porcheddu company (1912).

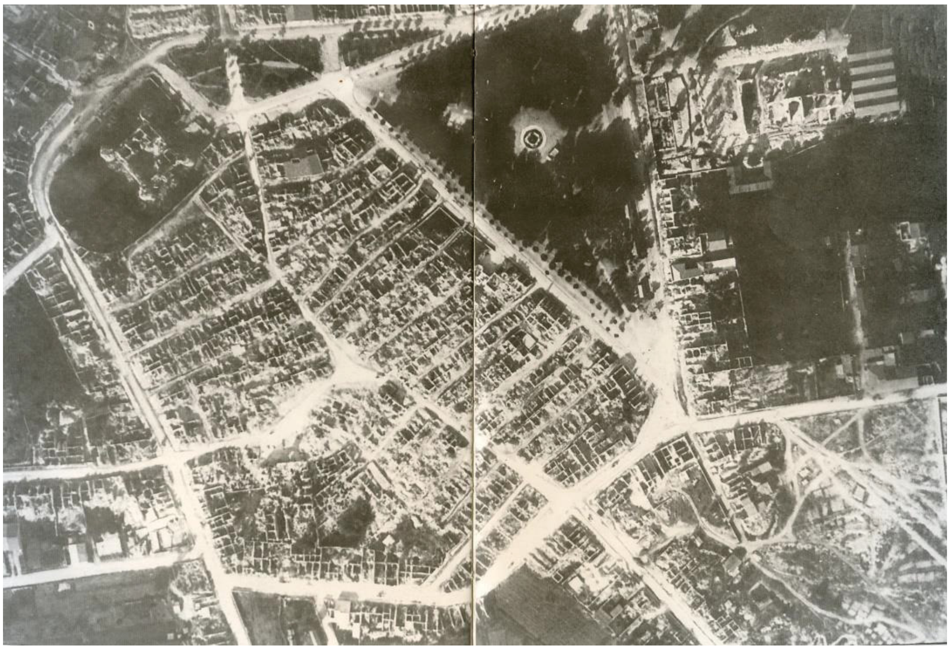


Fig. 1.9
Aerial view of Avezzano after the earthquake of 1915 (Mastroddi, 2005)

Fig. 1.10
Aerial view of San Francisco after the earthquake of 1906.

In Italy, after the end of world war I, there was still the necessity of the recovery of the damaged quaked areas. In this phases, the other monumental buildings interested by the earthquake, taking as reference the event of 1915 and the new one occurred in Maiella in 1933, were restored, major part of them with the insertion of reinforced concrete new elements. However, as already happened in the Ten years, this experimentation was interrupted due to the beginning of world war II, which arrested established preservation plans. Furthermore, in this case the war caused more damage to the buildings due to bombardments. Lot of monumental architectures, such as castle and palaces, were used as defensive headquarters from German soldiers, and so were bombed by the Anglo-American army.

Phase 3

The second postwar represented one of the last period in which the restoration attempts found lot of available funds, thanks also to renewal and recovery actions by the governments. While in America the major part of the damaged buildings had been already restored, in Italy there were still some damaged buildings since the previous earthquakes, which did not find yet funds or adequate restoration projects [45]. In this last area, with the funds made available with the Cassa per il Mezzogiorno, lot of historical and monumental buildings were interested by the restoration projects, which redefine them after years of abandonment. In this period, in particular, lot of restoration interventions with the use of reinforced concrete spread all over the country. A particular case is represented by the activity of the Soprintendenza, which, in particular during the period of Moretti's superintendence, redefine the historic architectures in new form thanks the insertions of new elements in reinforced concrete.

This last phase, except some interventions conducted in the first years of the second postwar, had numerous interventions of restoration during the Sixty and the Seventy years of the last century. Lot of interventions in the Italian context uses the reinforced concrete as the solution the static improvement. Apart the necessity of recovery the historic buildings still damaged, this phase is characterized also by new quake phenomena, as the ones in Tuscania and Ancona, which involved new interventions in the other regions of study.

Also in this paragraph, it could be useful to make some considerations about the different periods, focusing in particular to the use of reinforced concrete in restorations and the development of the approach during these periods.

Considerations

One of the first aspect to consider in this evaluations is the use of reinforced concrete in the first years of the century. While the phase zero individuates the first experimentations, aiming to recreate the original aspects of architectures, as in the case of Viterbo, during the following period the use of this new technology represents the solution to the necessity of urgent recovery and structural improving, thanks also to the quick realization of the works. In this case, specifically for the Italian cases, an important reference can be referred to the national laws which the government established after the first important quake event which interested the southern part of the country: the earthquake of Messina-Reggio of 1908, 1908, involved the first laws about seismic prevention, with specific chapters about new constructions, reconstructions and recovery interventions. In this case, also the application of reinforced concrete elements to the existing buildings was suggested [46]. With the phase 2, reinforced concrete received from the Athens' charter the "blessing" of its use in restoration, sometimes as the only one solution in restorations. The new available funds, which are the New Deal in America – during phase 2 – and the Cassa per il Mezzogiorno in Italy – during phase 3 – let the use of reinforced concrete widespread in the major part of interventions, letting other problems which will present only in last decades of the 20th century and with the new destroying events of the 21st one.

notes

[30] The Athens' Charter for the Restoration of Monuments, released in 1931, will be analyzed and studied in the specific chapter, cause of its importance and effects in the worldwide restoration field.

[31] Reinforced concrete then existed as a multitude of patented 'systems', or methods of disposing reinforcement, controlled by patentees. Among these, the most prolific was Francois Hennebique's French-Belgian system. Hennebique's success was due not only to the system itself; it depended largely on the specialist commercial-technical organization which he evolved, and extended worldwide, to control both the design and construction of his reinforced concrete works.

[32] The restoration intervention of the Loggia dei Papi in Viterbo represents an importance application of the new modern system in Italy; due to this importance, and also to the national impact on the theories and following experimentations, the intervention is studied in the specific chapter.

[33] Ibidem.

[34] For each American area the use of reinforced concrete represented a news in the material overview.

[35] The earthquake has been estimated about 7 degree Mgw in Richter scale; even if the instruments of the time were not able to evaluate the intensity of the event, the impact on the buildings was of the 12th degree in Mercalli scale, as the complete destruction.

[36] According to the differences of the materials and forms, on the same building they can be activated different typologies of "response" (it could be useful to cf. Borri's works cited in bibliography).

[37] The earthquake of Messina-Reggio is considered one of the most catastrophic event of the Twentieth century. The quake had been estimated of 7.1 Mg in Richter scale and it provoked spread damages in the cities of Messina and Reggio Calabria, southern Italy, causing the collapses of almost all the buildings and more than 75.000 victims (RMS, 2008; Prino et al., 2009).

[38] The earthquake of Messina-Reggio, which also followed other quake events in the same areas, represented one of the first times in which the national government and the corps of constructors were aware about the necessities of new guidelines for the new and existing structures. In this way, the Regio Decreto of 1909 established the first guidelines of constructions aiming to limit and avoid damages from horizontal stresses (Regio Decreto, 1909). This aspect will be analyzed in the Chapter 2, in the section "before the rules".

[39] In this phase the interested are of United States is the only California, the restoration works in Texas started only after the twenty years.

40 Early restoration had been pursued under the auspices of local associations; only years later, from the Thirty years, federal association and authorities managed the restoration projects of the Californian missions (Aiken, 1983).

41 CCC, an association of civil engineers unemployed, which during the period of the Great Depressions started to analyze and study the missions.

42 The New Deal was a series of programs, public work projects, financial reforms, and regulations enacted by President Franklin D. Roosevelt in the United States between 1933 and 1939. It responded to needs for relief, reform, and recovery from the Great Depression of 1929.

43 As the CCC, the HABS constituted a federal program established in the Thirty Years

44 It is clear the aim of the architect from his notes. During a drive along the highway north of Santa Barbara, he noticed the ruins of the missions: "I turned onto a rather poor road and drove until I came to the old ruins of the missions [...]. It was in a very sad state, there had been considerable vandalism, and there was no apparent interest in anybody as to doing anything to preserve the ruins, which had gone into decay over the better part of a century, I got out of the car and walked about [...] Many of the walls had disintegrated due to corrosion by rain and wind and melted away until they appeared to be nothing but the original earth. It come to my mind that his might be a wonderful project for a CCC camp to work on" (Kimbro et al., 2009)

45 In some cases, the conditions of the buildings after the earthquake were so complex that it took more time for the restoration project. One of these cases could be the Church of San Pietro in Albe (A_1|9), damaged in 1915, which had been restored only in the Fifty years.

46 Regio Decreto, 1909

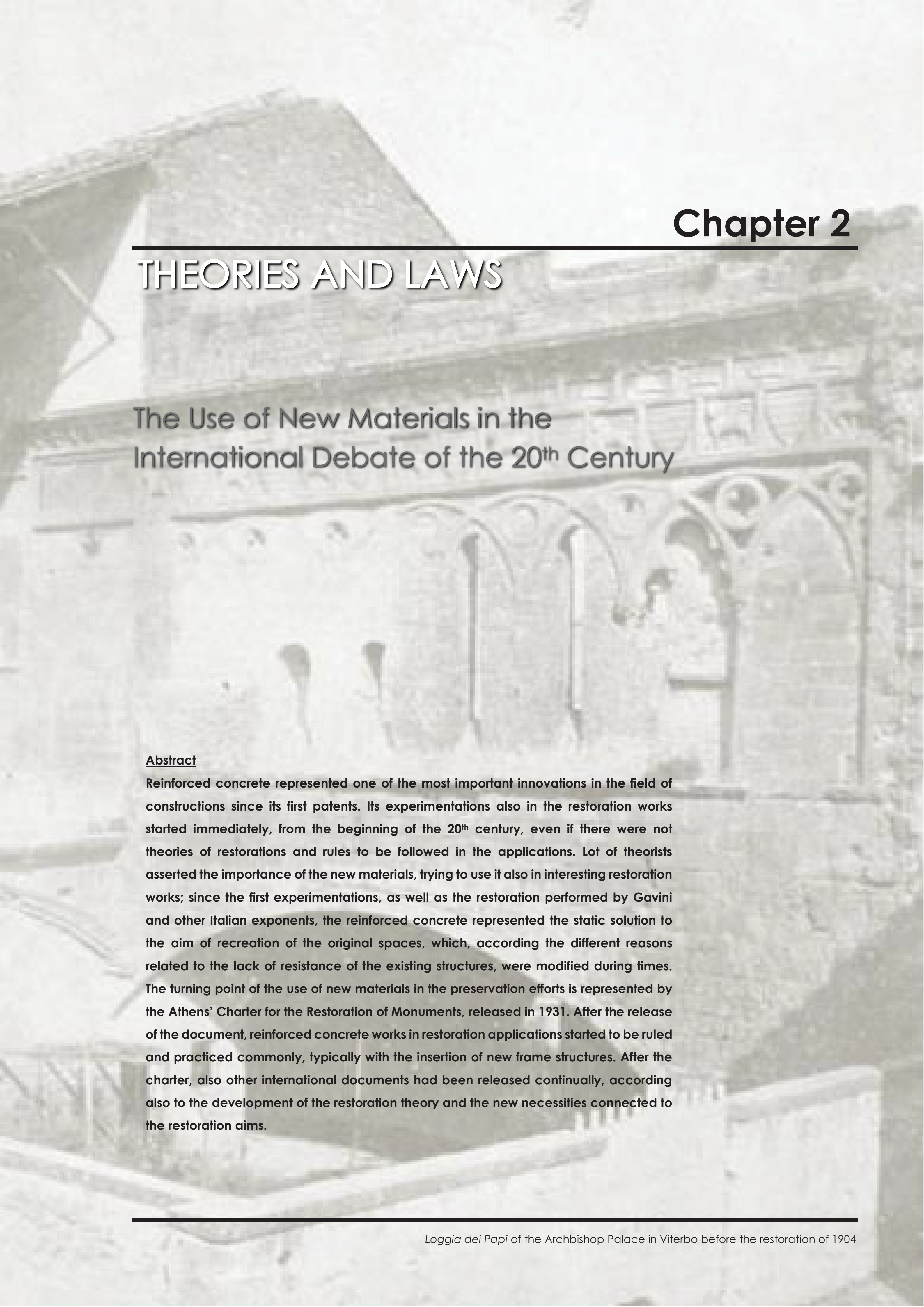
Chapter 2

THEORIES AND LAWS

The Use of New Materials in the International Debate of the 20th Century

Abstract

Reinforced concrete represented one of the most important innovations in the field of constructions since its first patents. Its experimentations also in the restoration works started immediately, from the beginning of the 20th century, even if there were not theories of restorations and rules to be followed in the applications. Lot of theorists asserted the importance of the new materials, trying to use it also in interesting restoration works; since the first experimentations, as well as the restoration performed by Gavini and other Italian exponents, the reinforced concrete represented the static solution to the aim of recreation of the original spaces, which, according the different reasons related to the lack of resistance of the existing structures, were modified during times. The turning point of the use of new materials in the preservation efforts is represented by the Athens' Charter for the Restoration of Monuments, released in 1931. After the release of the document, reinforced concrete works in restoration applications started to be ruled and practiced commonly, typically with the insertion of new frame structures. After the charter, also other international documents had been released continually, according also to the development of the restoration theory and the new necessities connected to the restoration aims.



Loggia dei Papi of the Archbishop Palace in Viterbo before the restoration of 1904

Capitolo 2

TEORIE E NORMATIVE

L'utilizzo dei nuovi materiali nel dibattito internazionale del Ventesimo secolo

Abstract

Il calcestruzzo armato ha da sempre rappresentato una delle più importanti innovazioni nel campo delle costruzioni sin dai primi brevetti emessi. Le sperimentazioni nel campo del restauro sono state avviate da subito, già dall'inizio del secolo scorso, sebbene non fossero presenti teorie del restauro o normative internazionali cui fare riferimento. Molti dei teorici del restauro in ogni caso confermavano le possibilità e l'importanza dell'uso del nuovo materiale, proponendolo anche in alcuni propri progetti di restauro. Sin dalle prime sperimentazioni, al pari anche dei restauri eseguiti da Gavini e dagli altri esponenti italiani ad esempio, il calcestruzzo armato ha rappresentato la soluzione statica all'intento di voler ricreare gli spazi originali di edifici che, in seguito alle modifiche indotte dalle carenze strutturali, avevano modificato il proprio aspetto. Il punto di svolta per l'utilizzo dei nuovi materiali nel restauro è rappresentato dalla Carta di Atene per il Restauro dei Monumenti del 1931. Con l'emanazione del documento, è stata avviata una fase di utilizzo normato e diffuso del calcestruzzo armato, spesso mediante inserimento di strutture intelaiate all'interno dell'apparecchiatura esistente. In seguito alla carta di Atene, sono state divulgate le altre teorie e normative del restauro, in accordo anche a quelli che sono stati gli sviluppi della materia e dei fabbisogni relativi alle opere di conservazione.

Introduction

After the description of the research areas and the split of the analysis periods, it becomes fundamental also to understand the development and the impact of the most important theories, international and locals, which ruled the applications of the modern materials in the restoration fields. According this overview, this section intends to focus on the different theories and assertions which characterized the international debate.

In particular, the dispute about the use of modern materials in the restoration fields is firmly influenced by the first applications, pursued since the beginning of the century in the analyzed context. The restoration works realized in Viterbo, in the Loggia dei Papi of the archbishop palace of the city aimed to recreate the original aspect of the loggiato before the consolidation interventions, which closed the arches. Furthermore, the quick application of the new technology in the construction sites, together with the necessity of fast recovery of places, justified the use of reinforced concrete also in the restoration/reconstruction works of San Marco's bell tower in Venice. Other interventions, pursued years later, as the Mole Antonelliana, certified the spread use of the material also in the preservation and recovery applications. The intervention represented a significant starting point of the modern materials' use also thanks to the assertions of the most important Italian figures of the period, such as Boito and Giovannoni, and their contributions, which affected the international debate.

The first years of Twentieth century were characterized by a series of events which test the historic built heritage in Italy; in this period, the historical built heritage found a critic phase due to the most important seismic event of the century, as the earthquakes of Messina in 1908 and Marsica in 1915; both events had a huge impact on the territory, causing not only a high number of victims, but also lot of damages to the historic structures. The same effects were verified in California, with the two different violent earthquakes which occurred in the period between 1906 and 1925, respectively in San Juan and Santa Barbara; as well in these cases, the events involved a huge number of victims and several damages to the historic buildings of the interested areas. With the target of avoiding additional damages and collapses, lot of urgent interventions were necessary for improving the structural safe.

But the most meaningful operation and turning point of the century had been represented by the Athens' Charter for the Restoration of Monuments, released in 1931, in which the reinforced concrete, together with the new technologies, finally found its primary and official role in the preservation approaches. The document asserted the use of modern technologies, and also the importance of relations among the integrations and the existing elements, letting the restoration in anastylosis where possible. The use of reinforced concrete became officially admitted: in this way, thanks to the development of the technology since the first experimentations and the new guidelines of the applications, the use of the modern material became omnipresent.

Since its release, the document obtained so much importance to involve the release of local theories and laws, due also to the influence by national movements. In Italy, for example, the use of new materials in restoration is the main topic in many debates. The Carta del restauro (The Charter for Restoration), issued in 1932 is considered the first official guideline in Italy on restoration. It asserts that all intervention of restoration must use modern technologies: this is one of the key points of the theory of “scientific restoration”. Also in the Carta di Venezia (Venice Charter) in the second postwar, all new and modern structural preservation technologies are allowed, but their efficacy must be demonstrated by scientific data and experience. Thanks to the contribution of Roberto Pane, Pietro Gazzola, and Cesare Brandi, who originated theories of critical conservative conservation, the role of reinforced concrete is of primary importance.

In the United States, the preservation strategies did not approach restoration and conservation concepts in a formal way: the only guidelines on restoration of historic buildings were the building codes, or general rules for new construction. Established in 1927 and locally determined, they allowed conservation only after analysis of damage; in particular, if the building presented damages affecting over 50% of the structure, the only allowed approach would have been the demolition and rebuilding. Reconstruction must follow codes which were required for new construction. In the section of codes dedicated to material, fire safety was a substantial concern that can be resolved by using reinforced concrete. Only after the release of other specific documents, involving major interest in the preservation efforts, the historic preservation started to have its independence in the construction fields.

From the publication of the work of Gustavo Giovannoni [1], the situation all over the world changed dramatically: the world wars and the natural destroying phenomena, such as the earthquake - which characterized particularly the Italian and Californian context - with their destruction, changed radically the aspect of the cities. In this way, the preservation rules and theories started to be literally applied in the reconstruction phases, in particular from the second post-war; this period became one with the largest number of reinforced concrete interventions on historic buildings. This time is characterized by the larger use of reinforced concrete thanks to the “maturation” of the critic mindset on the restoration approach and also to the quick development of the technological purposes [2].

Structure of the Chapter

Aiming to define the most important movements and positions in the international debates, this second chapter of the work is divided in more paragraphs, analyzing the different situations before and after the release of the Athens’s Charter. In particular, the first phase of the chapter aims to redefine the most important approaches to the preservation with reinforced concrete before the release of the international document, focusing not only on the single interventions, but also to the main important characters and their assertions. In this part, thanks to the analysis of some of the prominent interventions which characterized the first years of the 20th century, there are reported the most fundamental theories of restoration, trying to correlate them with the experimentations of reinforced concrete.

Instead, the second paragraph of the chapter intends to focus on the importance of the Athens' Charter for the Restoration of Monuments and the following different theories and rules, focusing in both areas of the study and trying to identify also the most important figures of the periods. This last part, taking as a reference period larger than the first paragraph, is lingered on the most important documents and rules.

notes

[1] Giovannoni, 1931.

[2] Carbonara, 1997.

2_1

"BEFORE THE RULES"

Use of the new materials before the international codes

"Doctrines" of restoration

Before the analysis of some interventions, according also to the use of reinforced concrete, it could be useful to analyze the Italian context with the first *"doctrines"*[3] of restoration, and the most important theorists. In this period the figures of Boito and Giovannoni were primary for the definitions of the new theory of restoration, trying also to rule the use of other materials during the recovery efforts.

The philological restoration of the end of 19th century represented the first real attempt of new restoration theories, trying to balance all the tendencies of the periods before, as the theories of Ruskin and Viollet Le Duc [4]. This target of balance employed also the importance of historic aspect of the building and the research, avoiding the attempt of stylist refurbishing.

Camillo Boito

Camillo Boito [5] aimed to rediscover the method of restoration, finding a free language and independent from the previous assertions and methods, in a way to give back eminently the Italian organic architecture, justified and justifiable in every part [6]. In this way, he asserted the historic methods with the analysis of the facts, documents - applied for each monument – in the preparatory phase for the architectural operations on buildings. In this way, the position of Boito displayed in an opposite view according to the one of Viollet Le Duc.

> *"When the restoration had been conducted with the theory of Viollet Le Duc, that can be called the romantic theory of restoration, […] I prefer the bad restorations to these works; while these last, thanks also to the charity ignorance, let me distinguish the older parts in comparison to the new ones, the other restorations make me perplexed, favoring also a hard study of the buildings, in which the new elements are not recognizable."* [7]

The assertion of Boito, in clear contrast to the method of Viollet Le Duc, showed also one of the aspects which had been a central point of his theory of restoration, as the recognizability of the new elements. Few years later, during a conference in the Universal Exposition of Turin in 1884, he continued to assert the fundamental criteria of restoration, expressed in two different main points:

> *"We need to do the impossible, we need to do miracles for preserve the monument in its old artistic and picturesque aspect"*
>
> *"We need to make the completion, if they are indispensable, and the additions, if it is not possible to remove, show themselves as works and elements of today".* [8]

As also in this case, Boito is strongly convinced to make in evidence, with a kind of recognizability, the new elements, trying to recovery and preserve the monuments. All these aspects, which characterized also the entire activity of Boito, were summarized in the famous eight points of the restoration, released in 1893 [9]:

1. Differences of style between new and old;
2. Differences of factory materials;
3. Eliminations of ornamentations;
4. Show of the old removed pieces, next to the monument;
5. Dating of each new elements of the restoration date;
6. Epigraph on the monument which shows the restoration;
7. Description and photographs of each phase of restoration, inside the restored building or in a closer place, or description published on the newspaper;
8. Notoriety.

As said before, all these aspects can be scanned according to the successive realizations and applications of reinforced concrete, in particular in some works realized in Abruzzo[10].

The Loggia dei Papi

After few years the assertions and theories of Boito, in Italy reinforced concrete system started to be used in the construction fields [11], and also for recovery and restoration approaches. One of the first experimentations which can be considered emblematical for the period and the development of both material and restoration theory is represented by the Loggia dei Papi, in the Popes' Palace of Viterbo, whose restoration intervention had been pursued between 1902 and 1906 (A_4|1).

After the surveys about the existence of the original windows, pursued in 1897, Paolo Zampi, the architect of the project, proposed the reopening of the original spaces, with the insertion of an auxiliary structures, in this case the upper architrave. Giulio De Angelis, director of the regional office of works, proposed the final project of restoration [12]. Before the realization of the project for the Loggia, there were performed other tests for analyzing the resistance of the original materials and for indicating the best way of operation. The insertion of a beam in reinforced concrete was suggested also for the availability of application of the covering original stones on the outside faces [13]. In the report of work in 1903, it is clear also the method of application of the new element:

> *"The beam, which will have the dimensions of 12.15m by 1.30m x 0.25m of section, will be put in place only with the decomposition of all the materials of the upper part of the loggia carefully, then, at the end of the work, recomposing them and all the possible original materials."* [14]

The realization of the works had been commissioned to Giovanni Nottola - which was also the president of the Association of Viterbo's Stonecutters - that disassembled the materials, numbering every removed element, and to the company Gabellini of Rome, which realized the beam in reinforced concrete.

The anastylosis work, pursued in the reassembly of stones and the disassembled decorative elements, can be considered one of the first example of modern restoration [15], with the aim of taking balanced the aesthetic and historic aspects, conserving the authenticity of the building[16] and using the modern and innovative technologies [17].

Fig. 2.1
The Loggia dei Papi in Viterbo before the restoration intervention (end of 19th century) (Scriattoli).

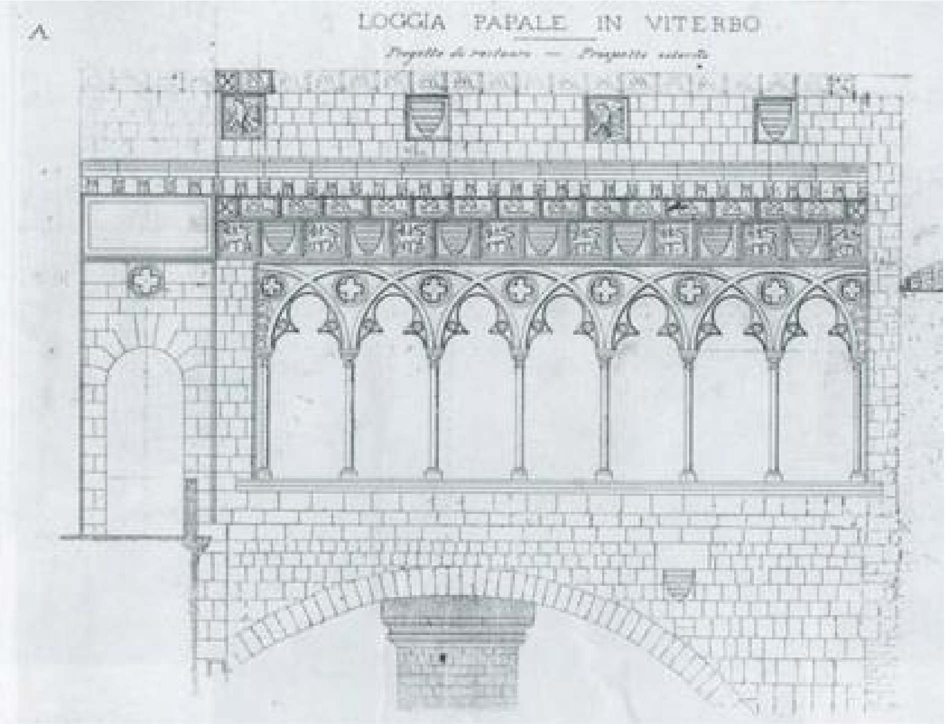
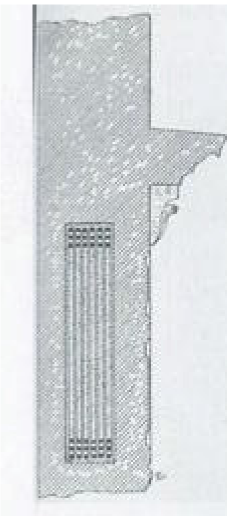


Fig. 2.2
Elevation drawing of the loggia. Project (Valtieri)



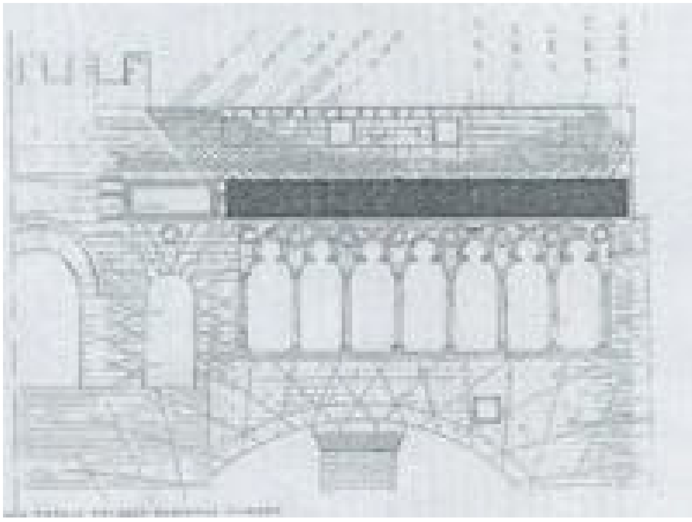


Fig. 2.3 - left
Section drawing of the reinforced concrete beam (1911)

Fig. 2.4 – right
Detail drawing for the restoration project of the eighty years, which identify the inserted reinforced concrete beam (Valtieri).

Fig. 2.5
The Loggia dei Papi today.

Gustavo Giovannoni

After Boito, the other main character of the restoration theory in this period had been Gustavo Giovannoni, whose theory of the scientific restoration followed the indications by Boito. Giovannoni [18] himself described the intervention in Viterbo, trying also to underline some characteristics which he proposed in his theory.

> *"As usually occurred in the medieval construction sites, the dimensions of the perforated wall were so weak and small, forming the loggias in a way similar to a lace. According this deficiency, since the first year after the realizations it was necessary to close the openings. A modern technology, as the reinforced concrete, let to reopen the wall in the new phase of the construction: a big beam, 1.30m high, had been positioned above the lines of the small arches, supporting the entire structures of the elegant loggiato, keeping hidden inside the masonry, giving safe and more resistance to the entire system and avoiding the structural role of the decorations as the small columns and arches."* [19]

Furthermore, Govannoni described also another important restoration, pursued in 1906 in the cathedral of Reims, in which the rosewindow had been recovered thanks to the insertion of reinforced concrete. After the description, the architect asserted the importance of the new material.

> *"As said about the consolidation restorations, the modern constructive systems of great efficiency based on steel and concrete, letting the stability of lack or bad designed structures, give new ways to the modern restorations."* [20]

According to the restoration position, Giovannoni has an empirical attitude, which starts from the reality of the individual building. He does not develop a real restoration theory, but identified five levels to refer to in the interventions on the architectural heritage, five types of interventions with an increasing impact on the building:

- The first level is characterized by the consolidation, as an intervention which has to be considered firstly and which has the objective of restoring the static compactness to the structures. It is useful to use also the modern means, which let to intervene also in not visible structures. According Giovannoni, the consolidation represents a desirable solutions as long as it remains hidden.

- The second level is characterized by the reconstruction, as well as the reassembly of the lost elements, called also "anastylosis"; this method is recommended in the archaeological areas, on the monuments which Giovannoni considered "dead", namely without any vital function for the contemporary society. This level is different from the "direct anastylosis".

- The third level is represented by the liberation, which aims to "clean" the architecture, removing all the additions which the history of architecture defines unrelated to the building.

- the fourth level is characterized by the completion, when it is necessary to close the lack of materials in the building, as long as the new additions are distinguishable. The completion intervention must not follow the style of the buildings, but it must denounce itself also in the material choice, following the rules of the simplicity.

- The fifth level is the represented by the possibility of the "innovation restoration", if the buildings does not present so much architectural quality and it grants to the modifications.

The restoration theory from Giovannoni can be considered of primary role according to the development of the use of new materials in the restoration applications, in particular the reinforced concrete. Also in this case, lot of the assertions of the architect finds in the works realized in Abruzzo in the first part of the century became the guidelines for the approaches to the buildings, in this case the works of the Soprintendenza [21].

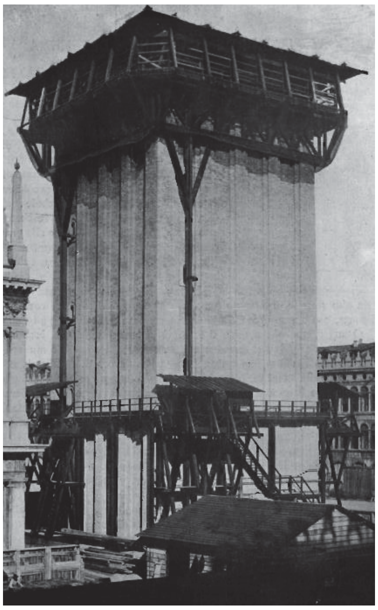
Frames in reinforced concrete had been already introduced in the first Italian laws after the quake events which hit Messina and Reggio Calabria in 1905 and 1908[22], referring in particular to the Regio Decreto of 1906 [23] and 1908 [24]. The rules were implemented also in 1912, with the other Regio Decreto 1080 of September 6th; however, they did not present any remarkable news to the previous Bourbon code in the anti-seismic field, which was considered still efficient in spite of the development of new materials [25].

Bell tower of San Marco and Mole Antonelliana

After the first experimentations, reinforced concrete increased its primary role in the field of restoration and recovery works, also in the reconstruction of the collapsed identity buildings. The immediate answer to this kind of catastrophic event, which still affects also the current debate, consists in the well-known "as it was, where it was" approach, although most of the times the real work brought to the "where it was and not as it was", with the "recreation of the external apparent aspect of the construction, with a kind of improvements (architectural or structural integrations differently from the previous state), hidden inside the miraculous formula of reinstatement of the status quo" [26].

The example of the bell tower of San Marco in Venice represented one of the most important cases. Collapsed in July 14th 1902 [27] because of the scarce evaluations about some works inside the building, the bell tower, after lot of years of debate about the reconstruction, had been rebuilt only in 1912. Apart the reasons which involved the reconstruction of the building according to the theory "where it was, as it was" [28] , the bell tower had been rebuilt thanks to a new structure, different from the original in masonry. In this case, the chosen material was the reinforced concrete inserted with frames in all the height envelope of the building. Luca Beltrami [29], the designer of the new project, asserted the necessity of reinforced concrete's use in the works, lighter than the system in masonry [30].

The reconstruction/restoration of the bell tower of San Marco represented and underlined the new role of reinforced concrete in the national context, pressing the necessity of new guidelines in the international debate about the new materials in restoration.



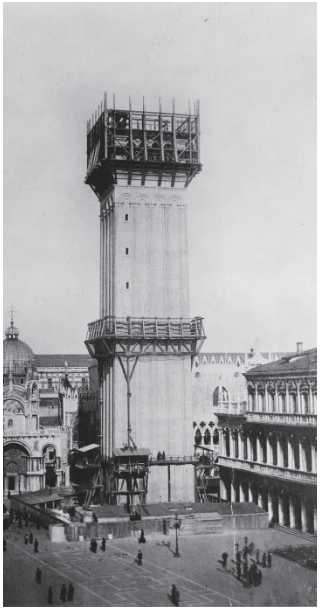


Fig. 2.6 - left
One of the numerous photomontage of the bell tower's collapse.

Fig. 2.7 - center
Reconstruction works of the bell tower of San Marco in Venice (1908).

Fig. 2.8 - right
Reconstruction works of the bell tower of San Marco (1911) (LIBC)

Fig. 2.9
The bell tower of San Marco rebuilt in 1912 (LIBC)

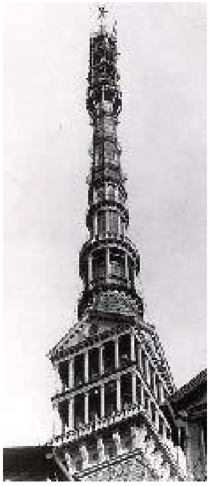



Fig. 2.10 - left
The spire of Mole Antonelliana during the work of Thirty years.

Fig. 2.11 – right
Interior of the Mole Antonelliana at the end of the work in the Thirty years.

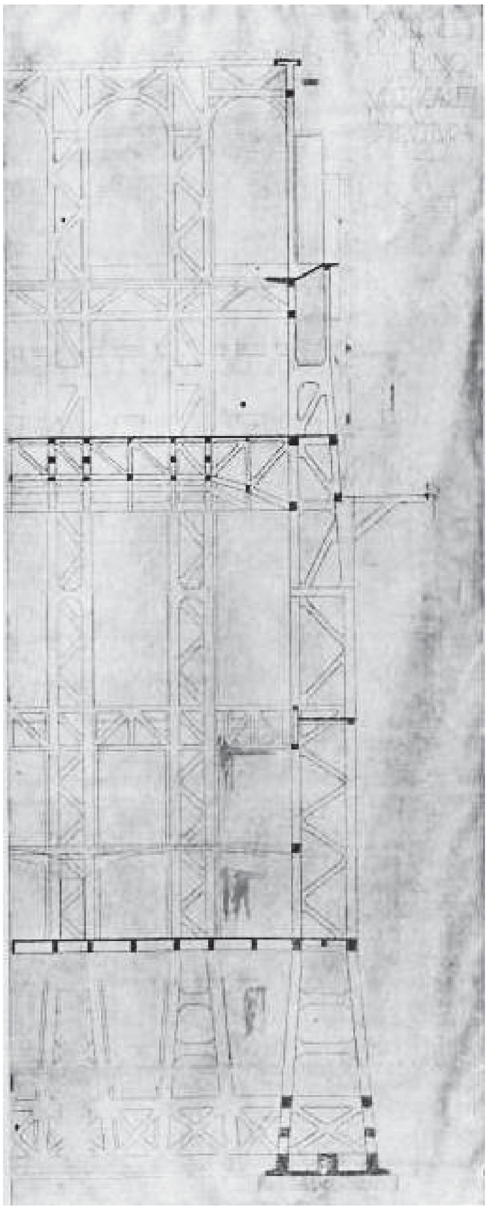
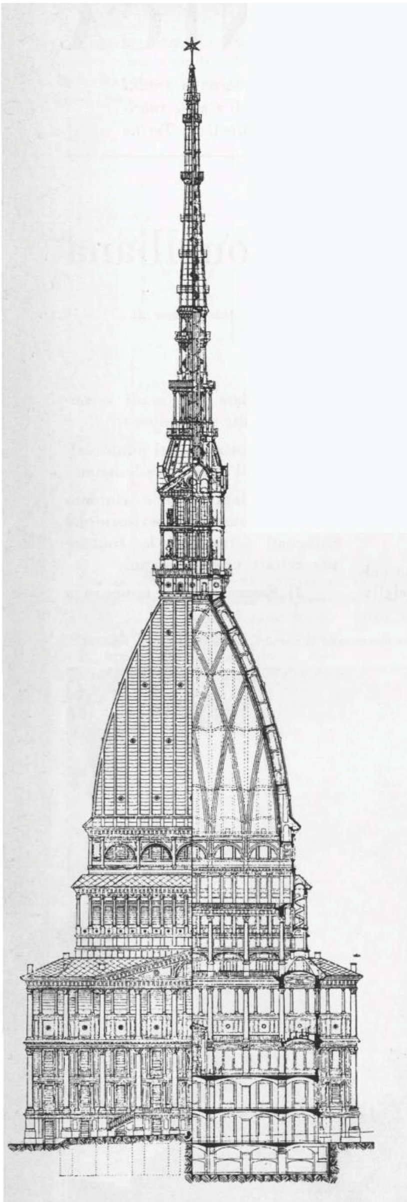



Fig. 2.12 - left
New structure of the Mole Antonelliana, designed by the engineer Pozzo (1931)

Fig. 2.13 – right
Section drawing of the Mole with the actual state at 1953 (1961).

Also, during the same years, the necessity of reconstruction of buildings and the recovery of historic architectures, due to the happening of destroying events such as the earthquake of Messina-Reggio and Avezzano, which involved several damages in all the built heritage, found in the reinforced concrete "the" solution of all these problems, increasing its role. One of the first supporters about the use of the new material had been Ignazio Carlo Gavini [31], one of the most important figure of the Soprintendenza of Abruzzo. In particular, his idea was fortified by also the stronger characteristics of this kind of structures according also their better resistance to the earthquakes.

This correlation is immediate because of the necessity of quick recovery operation of the historic heritage, caused by the earthquake of Marsica of 1915, in which Gavini must operate [32].

Also in Abruzzo's hinterland, after the first works of Gavini, as the basilicas of Santa Maria of Collemaggio (A_1|1) [33] and San Clemente in Castiglione a Casauria (A_1|2) [34], and the other directors and technicians of Soprintendenza, as Munoz, Riccoboni and Biolchi, continued in the use of new technologies in the structural reinforcement of the historic architectures with the reinforced concrete's insertions. The attempt of the restoration in this way, except some example in which the new elements in reinforced concrete had been left visible, focuses on the attempt of an aware and wise use of the new material, in a way to do not compromise the aesthetic aspect of the monuments [35].

In 1917, the restoration project of the Mole Antonelliana [36], designed by the engineer Pozzo, aimed to redefine the internal structure of the building with the insertion of a new structure in reinforced concrete, in a way to supply the necessary structural resistance which the masonry structure was not able to do [37].

> *"In its fundamental concept, the new project provides for the construction, inside the Mole, of a new structure majorly in reinforced concrete, able to substitute the existing masonry framework in catching the stresses transmitted by the dome and its base. The new construction raises completely independent and detached from the actual building elements. In chosen points, the old structures leans on the new one with a light forcing of the contact between the two elements, in a way that, in case of yielding, the old structure can be supported by the new in concrete."* [38]

However, the insertion of the new elements in reinforced concrete modified radically the interior aspect of the building, making necessary also some small breaks in the original vaults and floorings, letting the passage of the new columns[39].

Before the rules in the US

Relating to the American case studies, the situation is not so different from the Italian cases. In particular, there are some intervention which certified the use of reinforced concrete before the coming of the new theories. Before introduce some of the most important figures and experience it could be useful to explain also the development of preservation efforts of historic architectures.

The preservation movement in the United States began in the early nineteenth-century and occurred among two separate groups: the private sector and the federal government. Citizens were concerned with preserving buildings tied to historical events or figures. The federal government focused on creating national parks and preserving natural landscapes. Patriotism fueled early preservationists, who sought to protect buildings tied to important historical figures or events.

The first preservation group in the United States was the Mount Vernon Ladies Association of the Union, founded in 1853. The purpose of the organization was to save Mount Vernon, George Washington's home, from dilapidation. The founder, Ann Pamela Cunningham, raised funds to purchase the property and enlisted in each state the aid of other women interested in preserving the estate [40]. The Association served as the basis for future private preservation organizations with the intent of protecting historical landmarks and set the trend for preservation in the nineteenth century. Typically, individuals, mainly women, headed private preservation organizations concerned with preserving buildings for patriotic reasons. This began to change in the first decade of the twentieth century with the preservation and restoration of the Paul Revere house in Boston. While historically significant due to its association with Paul Revere, the house also had architectural significance as it was the city's oldest surviving frame building [41].

William Appleton, an architectural historian and supporter in the Revere restoration, founded the Society for the Preservation of New England Antiquities in 1910. This organization was less concerned with the patriotic connotations of buildings and instead focused on aesthetic, architectural significances. This set the precedent for architectural significance being a criterion in preservation. One reason for this was the influence of John Ruskin and William Morris on Appleton and others. The writings of the two were widely published and read by Americans in the later half of the nineteenth century. Their ideas that architecture served as a historical link to the past and should be preserved as part of national heritage, affected Americans who had previously seen buildings as only serving a utilitarian purpose. The role of private initiative continued in the early twentieth century. One episode that would specifically affect the future of preservation in the United States first was Colonial Williamsburg.

In 1923, W. A. R. Goodwin, a rector at a church in Williamsburg, Virginia, asked millionaire John D. Rockefeller to assist him in restoring colonial Williamsburg. Rockefeller accepted and the two began the first attempt to restore an entire city. The problem with the restoration was that many of the original structures had disappeared and required reconstruction. After Williamsburg, new preservation organizations with board members having academic knowledge and experience in history and architecture began surveying and protecting places of historical and architectural significance in their area.

> *"Ruskin and Morris would have viewed the reconstruction of Williamsburg in abject horror and considered it wrong because it produced a false history. The significance of Williamsburg was that more people recognized the intrinsic value of their built environment and increasingly sought to protect it."*[42]

In the late-nineteenth and early-twentieth centuries, the federal government also began to value America's resources and initially focused on preserving natural landscapes. Its early involvement in preservation began in 1870. The first action of the federal government was establishing Yellowstone as the first national park in 1872. In 1906, the Antiquities Act passed Congress and allowed the President to reserve public land that had pre-historic and historic significance to protect against vandalism. In 1916, the creation of the National Park Service further protected historic and pre-historic landscapes by creating national parks.

Even if the reference figures in the American context about the restoration theory had been Viollet Le Duc, Ruskin and Morris [43], the restoration fields verified a strong correlation on the development of the Italian theories, finding also some reference points in the assertions of Boito and Giovannoni[44]. However, in America the first movements in preservation started in the second half of the nineteen century, with the first nationwide preservation efforts, which continues and were stimulated by the celebration of the centennial celebration of the Civil War, leveraging from the patriotic education and the necessity of remembering the historical places [45].

According to the use of modern technologies, the American context had been interested by the presence of the cement companies [46], which involved the use of reinforced concrete with low prices and favorited the new materials also according to the fire resistance aspects; indeed, also the building codes, the rules relative to the constructions, suggested the use of reinforced concrete systems in the new buildings [47]. This mix of social participation, together with the local association efforts and fundraisings and the presence of the economical potentials, let the start to the restorations of historical and monumental buildings with the insertion of the modern technological elements.

Fig. 2.14
The Mount Vernon Ladies' Association. First group of participants.

Fig. 2.15
Capitol building in Williamsburg after the renovation works. (1934-ca. 1950).

Fig. 2.16 - left
Alfred Giles in 1898.

Fig. 2.17 - right
The office of Alfred Giles Company in about 1910.

Alfred Giles

In this context, one of the most important experimentations of the new materials had been promoted by the English architect Alfred Giles [48], who was the designer of one of the most important interventions of the area, such as the restoration works on the Alamo church, pursued in the Twenties and characterized the spread use of reinforced concrete elements [49]. Giles himself was convinced about the potential applications of reinforced concrete; his son, Palmer graduated in architecture with a thesis work regarding the use of reinforced concrete on water thanks.

While in Texas the experimentations of the new materials were related in particular to few cases, with the necessity of interventions due to also the importance of the buildings, as for example the Alamo (B_1|1), in the Californian areas the situation had been completely different. The earthquake of 1906, which hit the area of San Francisco causing lot of damages, and the event of Santa Barbara in 1925, as the Italian areas hit by the quakes involved the necessities of quick recovery and reconstruction, trying to use also the modern technologies for limiting or avoiding the seismic risk.

After two entire decades of experimentations of reinforced concrete, the new materials found its stable role in the recovery and restoration works, in particular with the release of the Athens' Charter in 1931, which summarized all the experimentations and the theories of the years later.

notes

[3] Carbonara, 1997.

[4] Ruskin and Viollet Le Duc proposed the new approaches to the restoration based on, respectively, on the anti-restoration – leaving the buildings in ruins, to a natural death – and the aesthetic approach – with the insertion of new elements, artistically compatible to the existing architecture.

[5] Camillo Boito had been one of the most important figure in the international preservation field. Born in October 30th 1836, he had been one of the first reference figure after the national unification in the field of arts and architectures, claiming the debate of the "National style". Proposing the philological restoration, he aimed to reach an Italian restoration theory, between the French "stylistic restoration" and the English "Anti-restoration movements".

[6]L. Grassi, 1959.

[7] Ibidem.

[8] Boito, 1884.

[9] Boito, 1893.

[10] In particular, it is remarkable how the theories of Boito were completely applied in some of the restoration works pursued in Abruzzo in the first years of 20th century, as for example in Gavini's works (Cf. Conclusions).

[11] Patented by the engineers Giovanni Antonio Porcheddu (cf. chapter 1).

[12] The restoration works had been completed by Pietro Guidi in August 1904 (cf. Guidi, 1911 and 1932).

[13] The use of the reinforced concrete beam, probably, had been suggested by the Scuola di Torino, which performed also the tests on the original materials, thanks also the tight collaborations of French institutes, which were performing the first experimentations with the new material.

[14] Valtieri, 2005.

[15] With the intervention, Gavini defined the restored Loggia as "revived" thanks to its new stability (Gavini, 1923).

[16] Even if the deassembleation and the subsequent reassembly of elements modified the original architecture.

[17] The reinforced concrete, which had been patented by Hennebique only few years before, presented the first official regulations in 1902-1903, the same years of the project.

[18] Giovannoni, 1913.

[19] Cf. G. Giovannoni, 1929.

[20] Ibidem.

[21] One of the restoration works referred to Giovannoni's theory and assertions can be considered the one performed by Ignazio Gavini and the Soprintendenza of Abruzzo in the first years of the 20th century (Cf. note 8).

[22] Italy, and its previous States before the national unification, represented one of the first place to set national guidelines and rules for seismic prevention and design. The first rules released in 1784, after another earthquake which hit the city of Reggio Calabria, represented the first laws in anti-seismic construction field in Europe. The *Istruzioni per la ricostruzione di Reggio* (Instructions for the reconstruction of Reggio Calabria city) provided for the use of transversal connection, able to connect and link every masonry walls (in that time, of course, the suggested materials as beams and tie elements were in timber). Also the Vatican State, in 1859, released a series of rule aiming to limit damages on buildings with quake event. After an earthquake happened in Norcia, the new laws for new constructions established geometrical limits of buildings and minimum dimensions of the structural elements (i. e. thickness of walls according to the height of the buildings or position of openings).

[23] Regio Decreto n. 511 of September 16th 1906.

[24] After the quake event of Messina-Reggio Calabria occurred in December 28th 1908. Both the quake events represented an important starting point for the beginning and the experimentations of reinforced concrete applications as anti-seismic solutions. Cf. also note 38 of the previous chapter. Cf. also Regio Decreto, 1908.

[25] Ciranna, Montuori, 2016.

[26] Carbonara, 2017.

[27] Alvise Zorzi in his "Venezia scomparsa" reported the moments of the collapse of the bell tower: "The crack on the side of the colossus opens frighteningly: the mirror which face the Basilica (of San Marco) bends apart and crashes while the crowd shouts a prolonged scream and a dark noise of ruins spreads, the huge pinnacle of the bell cell oscillates with two or three slow movements from right to left and from left to right, twisting the arches that hold and breaking them. The colossus collapses on itself and gives up. The earth wobbles, a gigantic cloud of dust rises and in it the golden angel sinks. The dust spills all over, like the ash of a volcanic eruption, and blinds the terrified people who scatter, breaking the shop windows in a mad escape." (from Alvise Zorzi, 1972).

[28] The reconstruction of the bell tower of San Marco in Venice constitutes a vibrant debate of restoration, according to the different positions about the reconstruction of the monument. The reconstruction according to the idea "as it was, where it was" had been suggested also by the necessity of recreation of urban and morphological architectural relationship among all the monumental elements of the main square (Carbonara, 1997). Giovannoni in his *Questioni* underlines also the importance of this kind of reconstructions, according to the reactions of the people before and after the reconstruction of the monument.

"Lot of people claimed for the reconstruction or not of the bell tower, for the re-proposal in a new style or in an imitative way. Everyone was right; but who was in Venice in those years in which the bell tower did not exist no more did not have doubts: Venice, without its mast was no more Venice. San Marco square had lost every meaning. […] But, in the unforgettable inauguration day, the powerful sounds of the bells, together with the whistle of the ships and the intense applauses of people celebrating the resurrection of the bell tower as the resurrection of the entire city showed the real reason of the necessary reconstruction".

If also it is not correct to argue of restoration (due to the complete reconstruction of the monument, as a false), in this case it could be proper, cause to the environmental monument which had been restored (Carbonara, 1997).

[29] Luca Beltrami was also scholar of Camillo Boito.

[30] After other polemics, Beltrami resigned as the designer of the bell tower project. After the resigns, the new committee of experts, whose president was Gaetano Moretti, confirmed the approach of Beltrami, proposing the reconstruction with a new structure in reinforced concrete.

[31] Ignazio Carlo Gavini was born in Rome in 1867. During his master degree in Architecture, he interested on the preservation of monumental heritage. Member of the Associazione Artistica tra i Cultori dell'Architettura – Artistic Association among the Architecture Enthusiasts – of Rome since 1895, he collaborated to the restoration woks on the San Saba Church, which occurred in 1910. He started to be employed in Regia Soprintendenza of Medieval and Modern Arts of Abruzzo and Molise as "foreign warrior architect "(cf. Miarelli Mariani, 1979) since August 1st 1916, even if there are some documentation which stated collaboration before this date. His activity is strongly connected to the necessity of "travel among the provinces of Abruzzi (Abruzzo and Molise) for long and short tracks" (Miarelli Mariani, ibidem). Fired in 1921, in the same year he obtained new commissions for some restoration works, under the direction of the professor Antonio Munoz, Superintendent to the Monuments of Lazio and Abruzzi; since 1923, the resulted as hired as architect, while he became director in 1931. He died in Rome in August 18th, 1936. (Felli, 2018)

[32] Ciranna and Montuori, 2014.

[33] Gavini, 1924.

[34] Gavini, 1926.

[35] All of the interested restoration works with the use of reinforced concrete will be analyzed in the specific chapter.

[36] Re, 2003.

[37] In May 23th 1953, the spire of the Mole collapsed due to the strong winds. The new carried restoration, designed by Vittorio Zignoli, provided the insertion of four triangular gables in reinforced concrete, aiming to support the steel pipe ideated to support the new spire for the winds effects (from Zignoli, 1961).

[38] *The structure provided largely the creation of pillars in reinforced concrete: each pillar comprised in its interior four different columns, positioned around the nucleus element and linked in a way to form only one monolithic element. In half of the height, precisely in the area of the parabolic arches, it had been designed a high stiff slab, obtained with reticular crossing beams, which divided the huge space of the Mole in two levels.* (from the relation of the engineer Pozzo, 1931).

[39] The broke areas of the vaults had been reinforced with ribbings in reinforced concrete around the holes (Pozzo, ivi).

[40] Weinberg, 1974.

[41] Jackson, 2004

[42] Jackson, 2004

[43] Becket, 1880

[44] Ibidem.

[45] Weinberg, 1974

[46] The report made by Eckel in 1913 showed and underlined the economical possibilities related to the use of Portland cement elements. After the European experimentations, in particular in England and Germany, from the last quarter of the century the productions of cements started in America. With the first experimentations pursued in 1872 on new buildings, the material production started to be spread all over the United States. In 1913, the year of the report, the United States produced more than twelve millions of tons of Portland cement. At the same period, in California there were seven plants - The Pacific Portland Cement Co. in Suisun, The California Portland Cement Co. in Colton, the Cowell Portland Cement Co. in Davenport, the Standard Portland Cement Co. in Napa Junction, the Riverside Portland Cement Co.in Riverside, the Golden State Portland Cement Co. in Oro Grande – while in Texas there were four companies – the Alamo Cement Co. in San Antonio, one of the first plants in US, the Texas Portland Cement Co., the Southwestern States Portland Cement Co. in Eagle For, the Southwestern Portland Cement Co. in El Paso (Eckel, 1913).

[47] In this case, also, the building codes did not consider the preservation as an independent field, in which the historic aspect must preserved. The only rules presented in the documents assert that the existing building, in case of recovery, must be interested by the same interventions of new constructions only if the interested part of the intervention represent more than the 50% of the original architecture.

[48] Hollers George, 1972, 2006

[49] The restoration of the Alamo will be studied and analyzed in the specific chapter, focusing in particular in the relation of reinforced concrete completion according to the original building.

2_2

THEORIES AND RULES

Development of rules, laws and theories from the Athens'Charter to the present day

The Athens' Charter - 1931

After the first experimentations, together with the necessities related to the use of reinforced concrete structures in restoration works, all the efforts aiming to reach an "agreement" with new guidelines for the modern means applications found the key point for the international debates and theory of restoration in the Athens' Charter for the Restoration of the Monuments, released in Athens in 1931 by the International Conference of Architects [50]. The charter in this way became the new reference point of all the following restoration interventions, thanks also to the ten different points of the document [51].

"I. The conference, in the convintion that the preservation of the artistic and archaeological heritage interest all the States which are guardians of the civilization, promotes that all the States will collaborate largely and concretely in a way to let the consertvation the artistical and historical monuments.

II. The conference has intended some guidelines about the preservation of monuments. It asserts that, even in the diversities of specials cases which need specific solutions, in all the States must be predominant the general tendences to avoid integral restitutions, respecting the existing in all its parts.

III. The conference intended the release of rules with the aim of historic monuments' preservation for each State, trying to conciliate the private and *public points of view, balacing them to the public interest.*[52]

IV. The conference certifies that the principles and technics exposed and pursued in the last years are inspired to a common purpose: the recreation of the lost volumes, with the original elements, is approved with new and distinguishable materials. Also, before starting all the restoration interventions, it is suggested to survey with attentions all the aspects related to the existing, in a way to plan the resolution technics.

V. The experts, according to the different comunications, assert the use of modern material in the reinforcement of the old buildings; also they approved the judicious use of all the resources of the modern technique, in particular the reinforced concrete. They also assert that ordinally all these reinforcements must be hidden in a way to do not alterate the aspect and the character of the building, recommending the use only in the interventions in which there is the possibility of conservation of the original elements "in situ" avoiding the risks of disfractur and reconstruction"

VI. The conference certifies that in these modern ages, the worldwide monuments are becoming more threatend by the natural agents, and so it raccommends the collaboration in each country of all the technicians involved the restorations – such as architects, phisic and chemical scientists – and the publications of the works and results. Also, the conference raccommendes the conservation of the original models, when they are still in good conditions, and the executions of molds.

VII. The conference recommends the respect of the character and phisionomy of the contexts and cities in the new building constructions, in particular in the areas next to the historic monuments. Is also asserts the elimination of poles and telegraphical cables [...]

VIII. The commission votes that all the States and their institutions publish an inventory of their national monuments, an archive with all the documents *about the historic monuments, dedicating also some publications of preservation works.*

IX. The members of the conference, after visiting some excavations activities in Greece, found in the works the example of the correct collaboration in the preservation and cultural efforts.

X. The conference, so convinced that the best warrantly of monuments' conservation is due to the respect of the population and the consideration of the local identities, asserts the necessity of young generation education to the local heritage."

In the ten points, it is remarkable how the previous experimentations and assertions by Giovannoni, Banalos and Leon [53] influenced the document [54]. Also, in the report of the international conference which enounced the document, it is certified that the problem about the monuments' preservation was widespread globally. The use of reinforced concrete, also, constituted a topic of debate, with the presentation of the Italian applications in Rome, with the re-composition of the Aedes Vestae in the Roman forum, the Loggia dei Papi in Viterbo, and also the churches of Santa Maria di Collemaggio in L'Aquila and of Sant'Andrea in Vercelli and the bell tower of San Marco in Venice [55]; in particular, of primary importance were also the studies about the reinforcement of the foundations of the Pisa's Tower [56]. From this point, the cultural worldwide context became affected by the avantguard theories of the moment and reinforced concrete started to be used in almost all the interventions. The Athens's Charter for the Restoration of Monuments represents a strong starting point for the restoration of historic buildings, representing the first real attempt which tried to solve "complex" situations for the historical preservation of monuments. The conference, and so the released document, aimed to give suggestions and technical and practical indications also for all the problems emerged in the previous times, characterized by the natural dramas due to earthquakes and hurricanes and by the destructions of the first world war. The document reached so much importance that, sometimes, it has been literally applied in the restoration, avoiding the critic analysis of the building and the scientific approaches and uses of methods.

After the release of the charter, both areas stated to have their own guidelines and rules in restoration woks, accompanying the new phase of preservation with the structural improving inducted by new elements in reinforced concrete.

Carta del Restauro - 1932

As regards Italy, in 1932, the year following the release of the Athens' Charter, the Consiglio Superiore per le Antichità e le Belle Arti [57] established the Carta del Restauro, the Restoration Charter, that can be considered the first official document release from the Italian National Council in the restoration field. The leanings of the document are the same of the Athens' Charter, with the important difference took from the Scientific Restoration theory by Gustavo Giovannoni: in this case, the document asserted and underlined the necessity of all the modern technologies in every intervention, for reaching scientific resolution restoration interventions. The most important target to be reached in the restoration intervention must be the preservation and the reinforcement of the monument, in a way to be more resistance to general decay phenomena. Also in this case, the completion in anastylosis must be performed only when necessary, with the attention of denounce the new elements with different materials. In this case, according also the theories of Giovannoni and the previous experimentations, reinforced concrete continued to have its important role in restorations.

HABS - 1934

In United States, after the first efforts in preservation pursued during the Twenty Years, the next wave of governmental preservation activity occurred during the Great Depression and addressed the built environment. In 1934, the Historic American Buildings Survey (HABS), which employed architects and historians during the Depression, began. This was the first recording of American historic buildings. The following year, Congress passed the National Historic Site Act of 1935. The Act had three provisions: it provided for the continuation of HABS; gave the National Parks Service the power to buy, preserve, and operate historic land for public benefit; and authorized the National Park Service to conduct a national survey of historic sites in the United States [58].

The coming of the world war II, with all the destructions to the architectural European heritage, brought again to newness the problem of restoration of monuments. In this case, giving more importance to the aesthetic aspect and, in particular, to the identity of the places according to their monuments instead of the historic one, the tendency to the restoration had been oriented to the reconstruction and reinstatement of the preexisting, risking also the creation of fabrication of history. With the outbreak of World War II, the US government's involvement in preservation slowed as other issues took precedence. As a result, the bulk of preservation occurred in the private sector. During the war, preservationists began to realize the need for a national organization that could establish long-term goals and coordinate the various independent preservation organizations.

National Council for Historic Sites - 1947

In 1946, members of several preservation-oriented organizations, including the president of the American Scenic and Historic Preservation Society and an historian of the National Park Service, met with David Finley, the Director of the National Gallery of Art. The men discussed the creation of a national preservation organization that would protect buildings and sites of architectural and historic interest. This meeting led to the creation of the National Council for Historic Sites and Buildings in 1947. The preservationists who formed this council wanted to secure a federal charter because it would provide national prestige and make the preservation organization permanent. Alexander Hamilton, chairman of the preparatory committee, suggested using the National Trust of England as the organizational template and namesake of the United States' organization.

In 1949, the organization received a federal charter and created the National Trust for Historic Preservation, a non-governmental organization comprised "of national, regional, state and local societies, and interested individuals" to advance preservation in the United States. The fundamental purpose of the NTHP was to preserve and interpret "sites and structures significant in American history and culture" by either arranging for the acquisition of property by preservation organizations that would provide preservation and interpretation, or acquiring the property if other options were not available. The NTHP sought to preserve buildings and sites in numerous ways.

Venice's Charter - 1964

After the end of this emergency phase, the international architectural culture asked again about the correct practices in restoration and, in the Second International Congress of Architects and Monuments' Technicians of Venice, in May 25th-31st 1964, there was released a new version of Restoration Charter, which was the Venice's Charter. In this case, the contributions of Roberto Pane, Pietro Gazzola and Cesare Brandi were primary important for the contents definitions. In particular, in most of the articles which composed the charter [59] all the modern means of structure and preservation were admitted for the intervention, thanks also to their efficiency demonstrated with scientific data of performances and last experiences.

The international impact of the Venice's Charter influenced radically also the American preservation system. The significance of the Charter to the American practice arises from the indirect influence of the document and its principles on the basic rules. In the National Preservation Act of 1966, the United State Congress enlarged the national policy to recognize and preserve historic properties. The Act provided for a greatly expanded National Register of Historic Places and created a system by which matching federal grants for preservation work would be channeled through the states for the preservation of properties listed in the National Register. This new system created several new documents The first was the National Register Criteria, an official way for determining the eligibility of individual buildings, structures, sites, districts and objects for inclusion in the National Register [60].

The Italian Charter of Restoration - 1972

Some years later, in 1972, the new Italian Charter of Restoration had been released; in this document the contribution of Cesare Brandi is relevant [61]. The important aspects enunciated in the documents are referred to the safety of monuments, intending the totality of preserving interventions carried out not directly from the work, differently from the restoration, intended as any intervention intended to maintain in efficiency, to facilitate the reading and to transmit the protected works to the future. The charters allow the new techniques and materials for the restoration, but only if approved from the Minister of Public Education, with the opinion of also the Central Institute of Restoration. In the appendix A of the document, it is expressly reported the potential use of concrete in other typologies of intervention, not considering the structural aspect. In the article no. 9 of the charter, it is clearly reported that:

> *"The use of new methods of restoration or materials, differently to the methods and material commonly used and admitted, must be approved by the Ministero della Pubblica Istruzione* [62]*, with the explained opinion by the Central Institute for the Restoration […]".*

According to the charter, reinforced concrete can be considered one of the method of intervention commonly used and admitted, even if it is not specifically written.

The Declaration of Amsterdam - 1975

With the "Declaration of Amsterdam" in 1975, the European Charter for the Architectural Heritage had been released by the Committee of European Council Ministers; the charter recognizes the singular role of the architecture in Europe as a common heritage of all the population and also asserts the purpose of the European members to cooperate among them to protect it. In one of the target, it is noticeable how it is important developing the education of the workers and encouraging the building factories to adapt them to all the new needs, also in the necessity of use of new and modern technologies in the recovery of historic buildings. The European Charter represented one of the last development of the restoration theory, aiming to identify the preservation efforts not only the group of operation which preserve the monument, but also all the intentions of preservation of the entire contexts, with the "integrated conservation, showing the insufficiencies of the "restoration of the single stones" independently from the preservation and the inclusion of the monument to a reason of life, of one or more compatible and desirably continuous functions. The integration between old artifact and function, so, but also the integration of the architectural object in its context, so the landscape, the city, the location"[63].

Secretary of the Interior's Standards - 1978

In 1978, a second American document was the Secretary of the Interior's Standards for Historic Preservation Projects, which defined what is and is not acceptable preservation practice.

> *"1. Every reasonable effort shall be made to provide a compatible use for a property which requires minimal alteration of the building, structure, or site and its environment, or to use a property for its originally intended purpose.*
>
> *2. The distinguishing original qualities or character of a building, structure, or site and its environment shall not be destroyed. The removal or alteration of any*

historic material or distinctive architectural features should be avoided when possible.

3. All buildings, structures, and sites shall be recognized as products of their own time. Alterations that have no historical basis and which seek to create an earlier appearance shall be discouraged.

4. Changes which may have taken place in the course of time are evidence of the history and development of a building, structure, or site and its environment. […]

5. Distinctive stylistic features or examples of skilled craftsmanship which characterize a building, structure, or site shall be treated with sensitivity.

6. Deteriorated architectural features shall be repaired rather than replaced, wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. […] Repair or replacement of missing architectural features should be based on accurate duplications of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural designs or the availability of different architectural elements from other buildings or structures.

7. The surface cleaning of structures shall be undertaken with the gentlest means possible […].

8. Every reasonable effort shall be made to protect and preserve archeological resources affected by, or adjacent to any project.

9. Contemporary design for alterations and additions to existing properties shall not be discouraged when such alterations and additions do not destroy significant historical, architectural or cultural material, and such design is compatible with the size, scale, color, material, and character of the property, neighborhood or environment.

10. Wherever possible, new additions or alterations to structures shall be done in such a manner that if *such additions or alterations were to be removed in the future, the essential form and integrity of the structure would be unimpaired.*

From 1980s to 2000s

The third American document about restoration, Definitions for Historic Preservation Project Treatments, spelled out the nature of different types of preservation projects. These delineated seven specific types of treatment, listed in order of the severity of intervention for historic preservation: acquisition, protection, stabilization, preservation, rehabilitation, restoration and reconstruction. The majority of projects have been for rehabilitation. Restoration and reconstruction projects have been mostly limited to a relatively small number of important historic properties under the jurisdiction of the National Park Services [64].

Since this point, all the following international documents, as the International Charter for the Preservation of Historic Cities, released in Washington in 1987, and the Cracow Charter released in 2000, proved the development of the restoration theories, moving to the study of entire contexts and social identities to be preserved, in which the historic buildings are central parts. The cooperation intent became fundamental and served in all the operation, and the use of new materials must be asserted by a series of proofs and authorizations.

notes

[50] Giovannoni, 1932.

[51] The ten points have been reported from The Athens' Charter of Restoration of Monuments, 1931

[52] Each State, in case of necessity and urgency, must have the only decisional power in preservation efforts.

[53] P. Leon and N. Banalos were two theorists which, together with Giovannoni, are considered as the promoters for the Athens' Charter.

[54] Giovannoni, 1932.

[55] Ibidem.

[56] Also in this last case, it is important to underline the new role of reinforced concrete and its use in the bell towers. After the collapse of San Marco's bell tower in Venice, the Minister of Istruzione named a special commission for the Pisa's Tower. Only lot of years after the nomination of the first commission, in 1935 the works started; the reinforcement of the foundations consisted in the insertion of micropoles and a slab in reinforced concrete (from Franchi Vicerè, 2005).

[57] The Superior Council for Arts and Antiquities

[58] Kimbro et al., 2009

[59] The Venice charter was composed of sixteen different articles.

[60] Stipe, Robert E. (1989)

[61] The charter had been structured as an officially law for preservation of historical heritage, being composed of a relation of introduction, twelve different articles, and four attachments.

[62] The Minister for the Public Educations, which was the authority which embraced also the preservation activities and the cultural heritage managing.

[63] Carbonara, 1997.

[64] Stipe, Robert E. (1989).

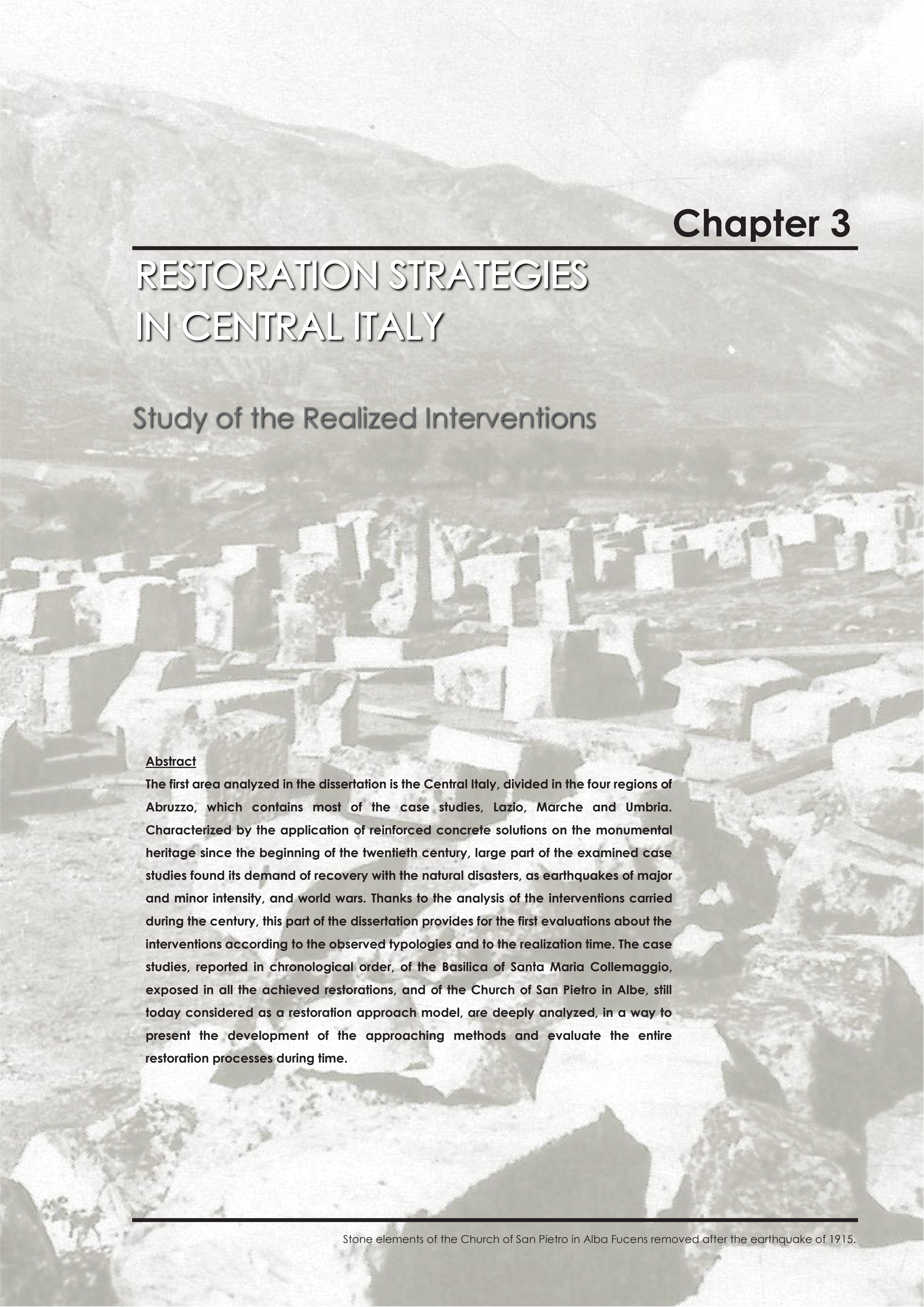
Chapter 3

RESTORATION STRATEGIES IN CENTRAL ITALY

Study of the Realized Interventions

Abstract

The first area analyzed in the dissertation is the Central Italy, divided in the four regions of Abruzzo, which contains most of the case studies, Lazio, Marche and Umbria. Characterized by the application of reinforced concrete solutions on the monumental heritage since the beginning of the twentieth century, large part of the examined case studies found its demand of recovery with the natural disasters, as earthquakes of major and minor intensity, and world wars. Thanks to the analysis of the interventions carried during the century, this part of the dissertation provides for the first evaluations about the interventions according to the observed typologies and to the realization time. The case studies, reported in chronological order, of the Basilica of Santa Maria Collemaggio, exposed in all the achieved restorations, and of the Church of San Pietro in Albe, still today considered as a restoration approach model, are deeply analyzed, in a way to present the development of the approaching methods and evaluate the entire restoration processes during time.



Stone elements of the Church of San Pietro in Alba Fucens removed after the earthquake of 1915.

Capitolo 3

IL RESTAURO E LE STRATEGIE NELL'ITALIA CENTRALE

Studio degli interventi realizzati

Abstract

La prima area di studio del lavoro di ricerca è costituita dall'Italia centrale, con approfondimenti specifici per Abruzzo, in cui è presente il maggior numero di interventi esaminati, Lazio, Marche e Umbria. In questo contesto, gran parte degli edifici analizzati e caratterizzati dall'inserimento di elementi in calcestruzzo armato trova il proprio fondamento e le proprie necessità d'uso nei danneggiamenti e nelle problematiche indotti dai fenomeni naturali, come i terremoti più o meno violenti che si sono susseguiti nella zona, e nei due conflitti mondiali. Mediante l'analisi di alcuni degli interventi realizzati durante il Ventesimo secolo, il capitolo intende fornire alcune prime valutazioni sugli interventi in relazione alle tipologie riscontrate e i periodi di esecuzione. I casi di studio della Basilica di Santa Maria di Collemaggio e della chiesa di San Pietro in Albe, riportati nell'ordine cronologico di esecuzione, evidenziano l'evoluzione delle metodologie operative sul costruito storico e forniscono, inoltre, un quadro conoscitivo più approfondito e completo degli interventi di restauro.

Introduction

Thanks to the explanation of the international overview of the previous chapter, with also the analysis of the global and local codes and theories, it is possible now to evaluate all the interventions, organized in the specific phases [1], according also to the specific context. With the first worldwide experimentations, it had been certified how the reinforced concrete started to be protagonist in large part of the restorations, even if its use was not ruled yet. Considering the Italian cases, the first interventions, as the reconstruction of the bell tower of San Marco in Venice and the restoration works on the Mole Antonelliana of Turin confirmed the spread use of the technology going ahead in time, involving the use also in the minor contexts related to the central area of Italy. In particular, large part of the first applications, which interested the area of Marsica [2] after the event of 1915, were characterized as sample insertions of new structural elements, avoiding the critical study from the restoration theories and necessities, as also already verified in the other restorations.

All the efforts in the use of reinforced concrete were pursued also by the reference authority of the place, such as the Soprintendenza, which, thanks also to the works of Gavini and Munoz firstly, Riccoboni and Biolchi secondly, tried to recover the local historic heritage using the modern means of technology. The area, also, is interested by the destructions involved by the events of the following years. The two world wars put to test the populations and also the main architectures of the territory; some of them were indeed used as defensive places for the armies (as the Piccolomini Castel of Celano[3]).

In this period, the use of modern technologies started to be commonly applied, thanks also to the supply of new theories and international documents. Also in the ordinary construction field, lot of the engineering and architectural studios and companies used the reinforced concrete as well as in new construction than in the preservations. Lot of designers and engineers identify in reinforced concrete structures the possible solutions in recovering and structural improving of existing buildings. Sometimes, also, lot of the designers were the promoters of this new technology after some experimentations in new buildings. In the area of L'Aquila, there were lot of studios and companies which started to launch the new materials.

After the WWII, the overview of the area showed the necessity of recreation of new houses for homeless and the recovery of their important monumental symbols, revaluating and protecting them from other damaging events. The recovery efforts and activities continued also in the second postwar with the works of one of the most debate figure of the Italian context, as the Superintendent Moretti [4], who performed a series of discussed restorations. After Gavini, Mario Moretti, considered one of the most discussed head of the authority in the last century, because of the strategies pursued in his restoration intervention, gave the start to other recovery and restoration activities, in which the structural reinforcement had pursued with the insertion of reinforced concrete elements.

The problems related to the reconstruction of the areas hit by the earthquake found in the use of reinforced concrete the common strategy, but with some differences. The residential buildings, simpler than churches, of one floor, had only top beams in reinforced concrete with two couple of columns along the perimeter of the house; in historic buildings, not only churches but also higher noble residential buildings, the reinforced concrete structures are inserted not only on the top, as the supporting systems for roofs, but also for each slab. The residential aggregates were designed and realized as copies of a single prototype, in which the designers analyze first the functional disposition, then the architectural form and finally the structure, as a consequence of the previous choices. In the restoration, the aspects of architectural recovery, structural solving and functional working had the same importance in the project phase. All these aspects underline the differences also of attentions and economic funds to the problem of reconstruction. In both cases, the use of concrete structures represented not only the use of a modern technology, but also the first experimentations for improving the resistance of buildings to quake stresses; in this time, all the technicians, not only engineers but also architects and heads of preservation authorities, were conscious about the risks of this kind of structures, made in masonry, poor mortar without any tying characteristics.

The other areas of research, as Lazio Umbria and Marche, except the examples yet analyzed, as the Loggia dei Papi in Viterbo, were interested by a series of restoration campaign only in the Seventy years, after some earthquake events which involved damages to the historic architectures and which caused the necessities of restoration, thanks also to special funds made available for the post emergency and recovery phases.

Structure of the Chapter

The chapter is divided in two different sections; in the first part, there are individuated the most important restoration experiences, focusing to some interventions, in which the use of reinforced concrete had a primary role – as the Basilica of San Clemente in Castiglione a Casauria (Pescara's province) (A_1|2) - the figures and the theories in the three different phases, trying also to identify the development of the used materials and restorations according to the identified periods. Also, in the first part there are also reported the impact of the disasters which interested all the central part of Italy in the 20th century, focusing in particular on the mentioned events, and trying also to individuate their impact on the territory.

The second part of the chapter intends to analyze some emblematic case studies, according to the different periods, areas and phases, and according to it is possible also to understand the development of the use of reinforced concrete: the case studies are the Basilica of Santa Maria of Collemaggio in L'Aquila (with the three different restorations to which the building had been subjected) and the restoration works on the church of San Pietro in Albe, in Alba Fucens (L'Aquila's province).

notes

[1] The phases in which the periods of restoration are divided. Cf. Chapter 1, par. 1_2, *The Periods, the Reasons of the Restorations and the use of Reinforced Concrete*.

[2] Marsica represent a large part of territory in the province of L'Aquila, comprised in the site where once there was the lake Fucino, one of the bigger in the Italian context. Now Marsica comprised lot of cities and villages, whose reference and center is the city of Avezzano, serious damaged by the interest quake of 1915.

[3] The Piccolomini Castel in Celano is analyzed also with other interventions on defensive architectures, pursued by the Superintendent Moretti (A_1|7).

[4] In the chapter, the activity of Moretti is referred to the use of reinforced concrete, there will be only few mentions about his approach in the most discussed projects.

3_1

RESTORATION TYPOLOGIES AND STRATEGIES

Approaching methods to religious and civil buildings

Ignazio Gavini and the post-1915 reconstruction

After the first experimentations pursued in Viterbo in the Loggia dei Papi (A_4|1), Abruzzo, and central part of Italy in general, became one of the most interesting areas for the new experimentations in the preservation field.

The earthquake of Avezzano, occurred in January 13th 1915, induced lot of damages and collapses[5], interesting not only the area of Marsica, but also the entire neighborhood[6]. Lot of historic buildings had diffuse damages with the earthquake, with in some cases also total collapsing. The irregular form of this typology of architecture amplified the effects of the earthquakes on the structures with different behaviors for each structural element; also, the material used in this buildings had not sufficient properties for increasing the resistance to the horizontal and shear stresses, typical of the earthquake actions[7].

The reconstruction after the earthquake of 1915 carried in a historical context of deepen transformation of the urban and architectural culture: these represented years of the prolific experimentations of new materials and construction techniques, whose applications extend from the new residential architectures to the restoration of the monumental heritage [8].

One of the first promoter of the new restoration campaign had been Ignazio Carlo Gavini. Thanks to his primary role inside the Regia Soprintendenza of Medieval and Modern Arts of Abruzzo and Molise[9], he pursued lot of restoration works in Marsica after the 1915 earthquake, aiming to give back to the old structures the necessary stability to resist to new events, trying to use the reinforced concrete. Already after the earthquake, in the description of the seismic history of Abruzzo, he found in the reinforced concrete the possible solution.

"We cannot deceive of the calm periods forgetting the danger which threatens above one of the most

> *beautiful Italian regions [10]. But the measures would be appropriated to the needs, and the same must be done in reconstructions and restorations, both in the civil residential than the monumental buildings: the used technical instruments must be able to avoid the repetition of disasters such as these which we complain."* [11]

Moreover, when he started to operate in the restoration campaigns, he underlined the necessity of the modern material in the aim of the structural reinforcement.

> *"Now a new material entered with a great fortune in the available means for restorations, and it is the reinforced concrete in its numerous applications. Due to its modernity, this material cannot be used in restoration works except with prudence, because of it constitutes the anti-aesthetic and opposed nature to the ancient materials. […] However, the reinforced concrete is a material appropriated to make great services in the restoration fields if wisely used. Rather, it gives the solution to problems which today are hard to solve.*
>
> *In this reinforcement hidden work reinforced concrete constitutes as only a mean of reinforcement. The "belts" of reinforced concrete have the role of chaining and also of avoiding the stresses from the roof – when applied at the top levels of the buildings. […]*
>
> *It is not possible establishing a uniform theory of application able to solve all the different specific cases. But the already realized applications of this structure type demonstrate the good purposes of the new material."* [12]

One of the most interesting works by Gavini, also introduced in the previous chapters, is the restoration of the Basilica of San Clemente in Castiglione a Casauria (A_1|2), Pescara's province, pursued after the damages of the earthquake of 1915, which amplified the existing cracks and damages already presented in the church.

Since the moment of the commission, Gavini was already aware about the decay state of the entire building, the events which involved the variations of the spaces, and the damages from the earthquake of 1915; the idea of the designer found the origin in the declared deepened acknowledge of the building, in a way to undertake specific decisions in the project and also according to the identity and spatial unity conservations. Among the complex of buildings, only the basilica had maintained its original aspect during the time. The basilica of San Clemente, realized between the 10th and the 12th century, had been interested by the alternation of construction sites, whose results are evident in the disposition of the plan and the elevations. Its rebirth found the beginning in the work of Pier Luigi Calore [13], who, thanks also to the writes of Gabriele D'Annunzio, gave interest to the building according to its romantic aspect due to the abandonment[14]. The architectural system in which Gavini operated resulted complex and denaturalized[15]. The plan of the building, following the latin cross, presents a system divided in three different naves, with transept and final aisle; the main nave, before the intersection with the transept, is also divided in two different areas with a big central arch, supported by pillars with backed against semicolumns. The areas divided from the arch have different height: while the side directed to the front is higher, the other side hides the intersection with the transept thanks also to the presence of lower arches; also, the presence of other small arcades with closed spaces for sacristies gives the perception of major length of the nave. The first step of the project had been referred to the necessity of stabilization of the entire main nave, in particular in the spans beside the central arch, supported by big pillars and semicolumns in the only longitudinal direction; in the other direction there were not linking elements, exposing the entire system to torsional behaviors, evident in the first cracks at the base of the columns; the restoration had been also focused on the stiffening of the central arch's supports in the transversal direction, with "wrong pillars" and arches in the wall at the planking level of the arch, overloaded with upper masonry elements till the height of the roof of the secondary naves [16].

The second phase of the restoration, which characterized the structural improvement of the buildings, had been centered on the main nave, targeting to reestablish the unity of the central spaces, according to the recognizability of the transept, reopening the lateral sides in which there were realized the sacristies. Also Gavini, before giving the authorization of this phase of work, had several doubts about the restoration point of view, which were expressed in the final report of the works:

> *"Were we sure that this part of the church, which we can see today it presents this few heights had ever reach the complete development? And if the differences of height can be due not to the suspensions of the work but to the old earthquake of 1348 [17], are we so allowed to raise a part of the building which took a particular aspect during all this time?"*[18]

The solution proposed by Gavini respected the preexisting: the central nave did not be raised to the anterior side height. With the liberation of the transept, the large rectangular room loses one side of its perimeter, with the separation of the presbytery and the liturgical spaces. Not being able to reconstruct the triumphal arch, Gavini decided to insert a new linking element, able to resist to traction and compression stresses: a beam in reinforced concrete. The same method had been applied in correspondence of the transept. The drastic choice of this use can be justified in the intention of recreating a wanted disharmony, far from the creation of an aesthetic perfect system, but only functional according to the static point of view. Furthermore, with this choice, Gavini himself was convinced about the reaching of the only one target of the restoration, such as the preservation of the monument.

San Clemente in Casauria (A_1|2), whose restoration finished in 1922, represented an innovative restoration, in which the use of the new materials took the primary role both in the aesthetic than in the structural aspects, as also Gavini suggested in its assertions [19].

In the following years, Gavini dealt with another intervention of restoration, in this case the church of San Giovanni Battista and Evangelista [20] (A_1|3), in the city of Celano, L'Aquila's province, damaged by the earthquake of 1915 with several damages and collapses in lot of parts [21].

> *"The earthquake of 1915 carried out an authentic artistic miracle, making collapsed the vaults of the right nave full of false decorations and giving back the underlying gothic vaults with beautiful frescoes."* [22]

The restoration intervention aimed to the rebuilding of the original system of the church – or better, its reproposition. The baroque elements which resisted to the quake were removed, and also the dome and the lantern were demolished; the last three spam of the left nave were rebuilt, and the central pillars were reinforced, with the use of concrete, for supporting the new vaults.

In this last case, the approach to the building pursued by Gavini changed completely in comparison with the example of Castiglione a Casauria [23].

What it is necessary to underline in this passage is the presence of reinforced concrete as a common mean in the recovery of the existing buildings. The years characterized by the necessities of recovery and reconstructions involved other interesting case studies, as the Basilica of Collemaggio (A_1|1), whose restoration had been pursued always by Gavini, and the church of San Pietro in Albe (A_1|9).

Fig. 3.1 – left
General plan of the Basilica of San Clemente by Gavini.

Fig. 3.2 – right
Interior of the basilica before the restoration intervention.

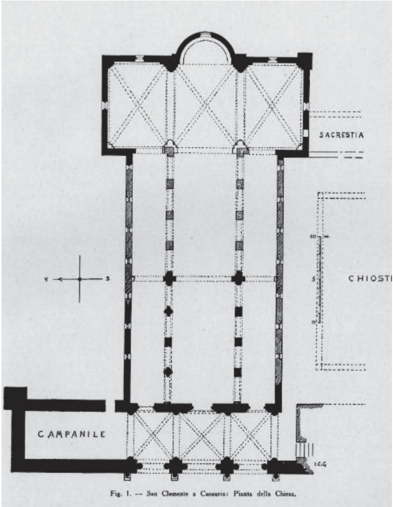


Fig. 3.3
Section drawing of the fist hypothesis of the restoration of Basilica of San Clemente by Gavini.

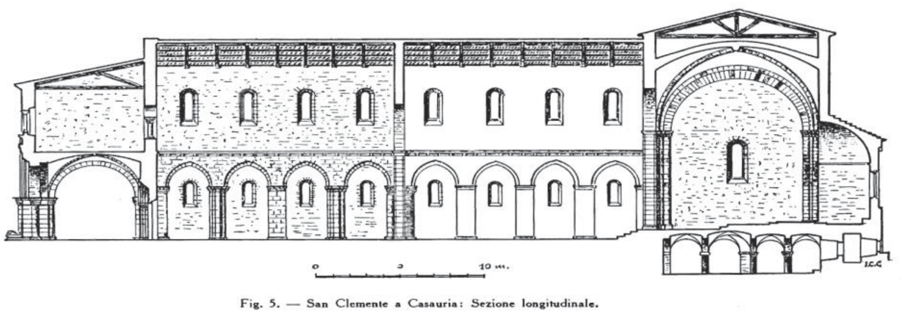
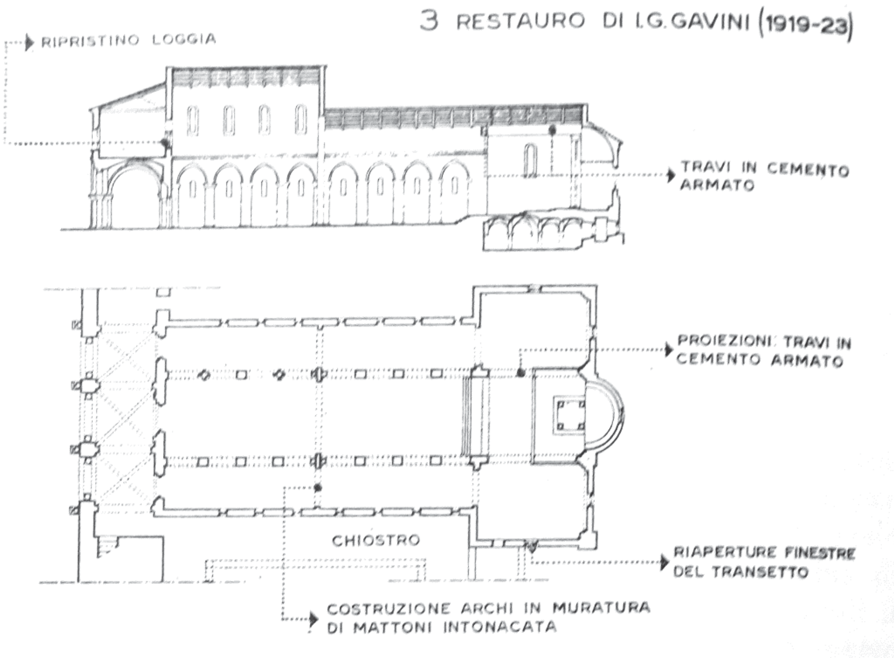


Fig. 3.4
Section drawing and plan of the restoration project of the basilica of San Clemente by Gavini. (Miarelli Mariani)



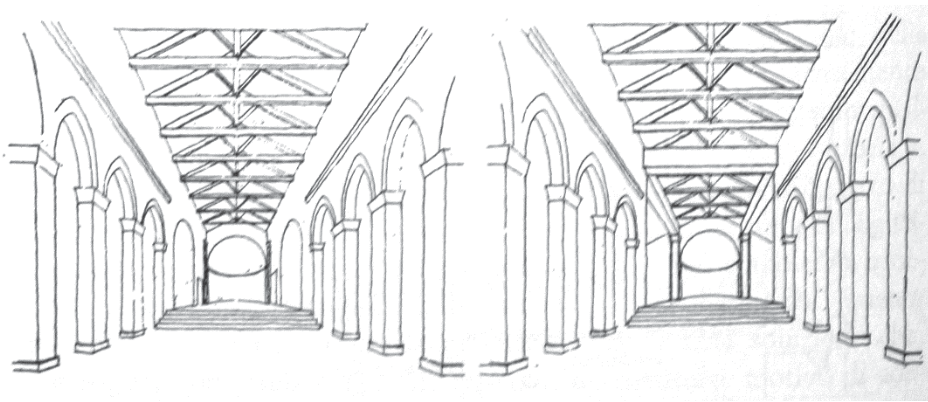


Fig. 3.5
Differences of the main nave view before and after the restoration (Miarelli Mariani)

Fig. 3.6 - left
View of the presbyterian area after the restoration (1926)

Fig. 3.7 - right
View of the presbyterian area after the restoration (1992)

Fig. 3.8 - left
View of façade of the church of Santi Giovanni Battista e Evangelista in Celano after the earthquake of 1915.

Fig. 3.9 - right
View of interior of the church of Santi Giovanni Battista e Evangelista in Celano after the earthquake of 1915.

The central Italian context in this period is characterized by the experimentations of the modern materials especially in the reconstructions and new edifications [24]. Giovannoni himself, called in the Social Commission after the earthquake of 1915, - aiming to promote the edification of new buildings in the areas hit by the earthquake – stated the necessity of the use of reinforced concrete frames as the solution to the weak resistance of masonry structures [25].

Restoration works in 1930s

The coming of the world wars stopped lot of the restoration works of the Soprintendenza, moving their start only in the Thirty years, which were characterized also by a new earthquake event, which occurred in September 26th 1933 [26]; weaker than the previous event of Marsica, with IX degrees of damage in Mercalli scale [27], the event interested 65 different municipality areas in Abruzzo, starting from the epicenter close to Maiella [28] among the provinces of L'Aquila, Chieti and Pescara, causing different and several damages in thousands of buildings and, sometimes, also some collapses.

During this phase, the necessities of reconstruction of the two damaged areas involved the spread use of reinforced concrete, both for restoration than in structural improving applications. The restoration intervention pursued in Magliano De' Marsi, L'Aquila province, in the church of Santa Lucia [29] (A_1|4); with the earthquake, the church presented lot of collapsed elements [30], as the dome, the roof and the clerestory of the main nave, making necessary the entire reconstruction of the building except the façade. The engineers Sabatini, firstly, and Pietrangeli [31], secondly, designed the restoration project, which took the period from 1928 to 1937. The project provided the insertion of a new structure in frame of reinforced concrete inside the walls, the rebuilding the collapsed walls in bricks; particular solution had been pursued in the new roof, with the creation of trusses in reinforced concrete, hidden by wood boards, able also to link the entire system to the main façade, which had been disassembled, reinforced and reassembled with the original elements, previous catalogued [32]. The foundation level had been improved with the insertion of foundation beams and, in correspondence of the central columns, plinths; also, the arches above the columns of the main nave and the cross vaults of the lateral spans were realized with reinforced concrete structures, covered with decoration in cement simulating stones, with top beams, in a way to connect all the frames around the perimeter of the building.

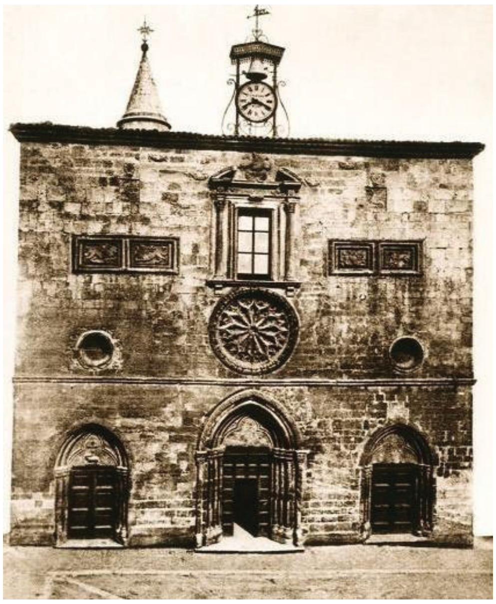



Fig. 310 – left
Façade of the church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.

Fig. 311 – right
Aerial view of the church of Santa Lucia after the earthquake of 1915.

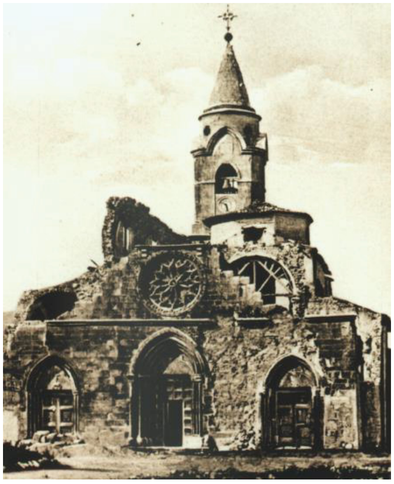



Fig. 312 – left
Façade of the church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.

Fig. 313 – right
Aerial view of the church of Santa Lucia after the earthquake of 1915.

Fig. 314
Church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.

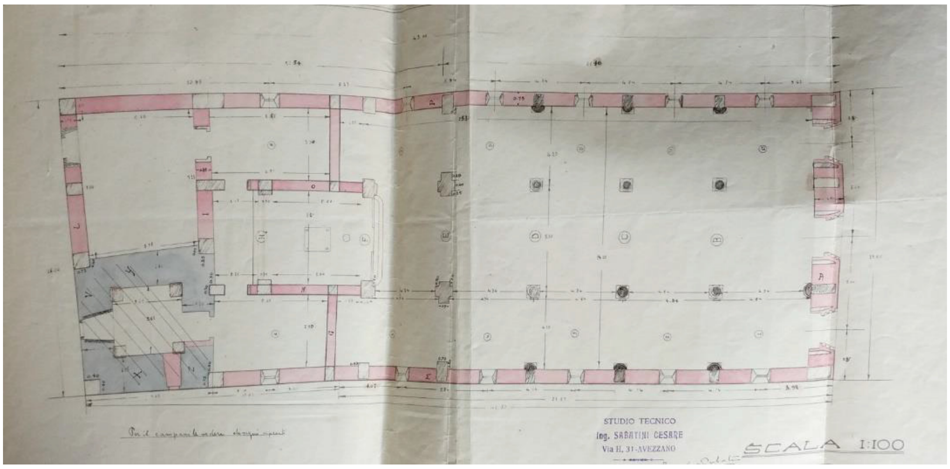


Fig. 3.15
Plan of the restoration project by Sabatini (1926, ASGCReg_Az)

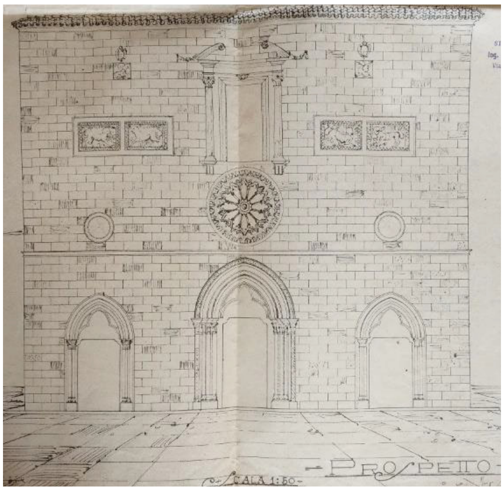


Fig. 3.16 - left
Façade of the restoration project by Sabatini (1926, ASGCReg_Az)

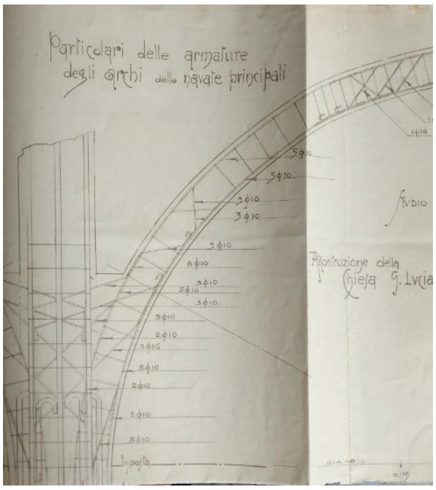


Fig. 3.17 – right
Detail of the reinforcement of the arches by the engineer Pietrangeli (1938, ASGCReg_Az)

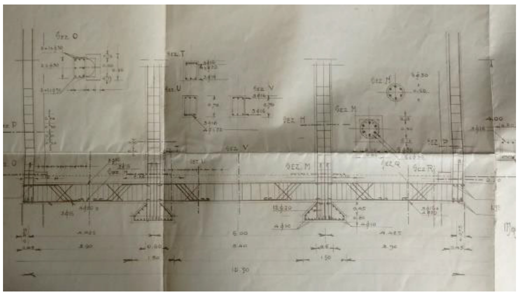


Fig. 3.18 - left
Detail of the foundation (1938, ASGCReg_Az)

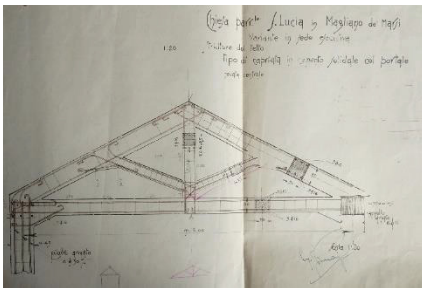


Fig. 3.19 - right
Detail of the reinforced concrete trusses (1938, ASGCReg_Az)

Also, some of the defensive architecture of the area were interested by complex restoration intervention, pursued by the Soprintendenza, with the collaboration of the most important companies of the period. One example is represented by the Piccolomini Castel of Celano [33] (A_1|7), whose restoration works were divided in more phases, because of also the suspensions of the work from 1940 to 1950 due to the war. As for the castle, the beginning of World War II stopped all the undertaken interventions, leaving lot of the buildings in their decaying state; the Piccolomini Castle suffered also additional damages because of the bombardments of Celano in April 1944 [34]. The restoration of the castle[35] attempted to reconstruct collapsed parts of the building, as well as the reconstruction of slabs and roofing systems. The works began and stopped in 1940, were reclaimed in the period from 1950 to May 1956. The main interventions concerned the introduction of new slabs, thanks to reinforced concrete systems, perimetral top and central beams with a roofing system in reinforced concrete and hollow tiles - mixed with reinforced concrete beams or trusses [36].

Restoration works after World War II

The restoration of the castle of Celano, represented one of the first intervention realized in the second postwar. While in the first postwar there were reached only few restoration works with specific funds, in this period the economic efforts of the Cassa per il Mezzogiorno gave the possibility to realize lot of the interventions. In particular, Abruzzo became one of the most engrossed areas, with the activity of the Soprintendenza, which started a new campaign of restoration with the superintendents Delogu, Matthiae and Moretti. While the first two operated in the first year of the second postwar, the last one handled in the entire Abruzzo, reaching lot of restorations[37]. Delogu, together with the architects of Soprintendenza, made the restoration of the church in San Pietro in Albe (A_1|9), located in Alba Fucens [38]. This work, pursued between 1955 and 1957, became one of the most appreciated interventions in the national context, involving also the commendation by Cesare Brandi. With the insertion of a new structure in reinforced concrete, the restoration provided for the disassembling and following reassembling of all the recovered elements [39].

In this phase of restorations, the activities of Soprintendenza are also characterized by the collaboration with the Genio Civile structures of L'Aquila and Avezzano, which employed a primary role also in some of the reconstruction and restoration projects. In L'Aquila, another intervention to be considered in this analysis is related to the Basilica of San Bernardino (A_1|11), located in the historical center. The church [40] had been interested by an intervention - under the superintendence of Gugliemo Matthiae - which, according to the approach a typology, founds its reference in the first Collemaggio's restoration[41]: in 1958, the Genio Civile and the Soprintendenza ai Monumenti e Gallerie dell'Aquila coordinated the works of the façade, aiming "to reinstate the cracked masonry" [42]. The works[43] provided the injection of cement mortar in the found empty spaces of the foundation, and, in particular, the insertion of a frame in reinforced concrete in the structure of the façade, with four columns with specific plinths and transversal beams of connection at three different levels.

> *"The works for the reassembly of the façade of San Bernardino provides the realization of a frame in reinforced concrete with three bond beams and four columns. The horizontal beams will be anchored also the perimetral and central walls at least for the minimum requested extension with an adequate reinforcement of steel bars."*[44]

After the interventions on the foundation and in the façade, all the disassembled elements had been repositioned.

In the same years, the work of the Genio Civile and Soprintendenza continued to provide restoration in the areas previously hit by the earthquake; in Marsica there were buildings to be restored, which, due to the high level of damages and the diffuse collapses, were still in precarious conditions. One of them is the church of Sant'Orante, located in Ortucchio (A_1|17), Marsica. With the earthquake, the church maintained only few elements[45], which were covered with temporary wooden integrations. The building remained in its ruin states for lot of years, being interest by the first restoration project only in 1960 [46]; the restoration project, designed by the architects Galvani and Dander of the Soprintendenza, aimed to maintain the existing walls, introducing a new structure in reinforced concrete, with different levels of bond and top beams and columns [47]. The other restoration pursued by Mario Moretti, as the castle of L'Aquila[48] (A_1|20) and Palena[49] (A_1|30), realized in the late Sixties and the early Seventies, certified the use of the new material in the structural reinforcement, with the insertion of perimetral top beams and roof in reinforced concrete.

Fig. 3.20
The Piccolomini Castle of Celano after the earthquake of 1915.

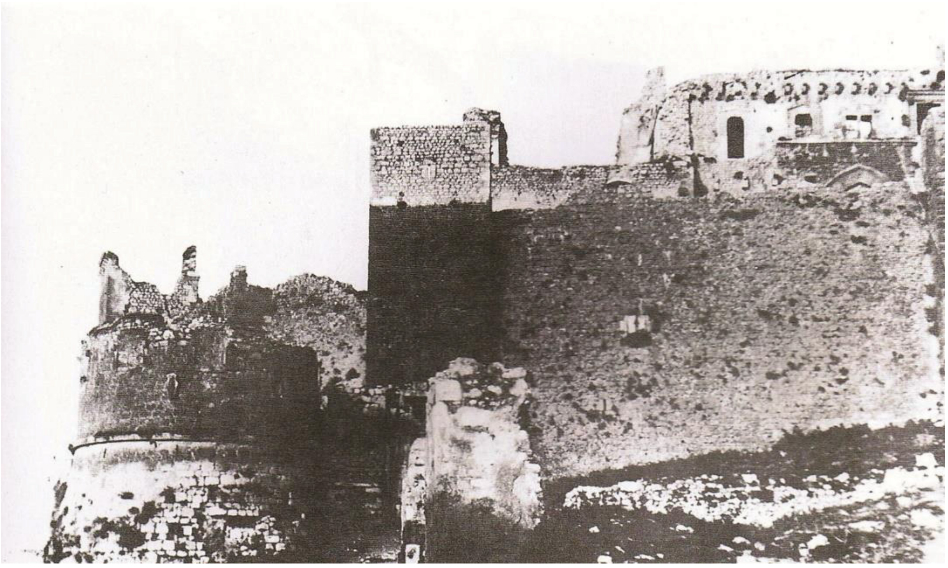
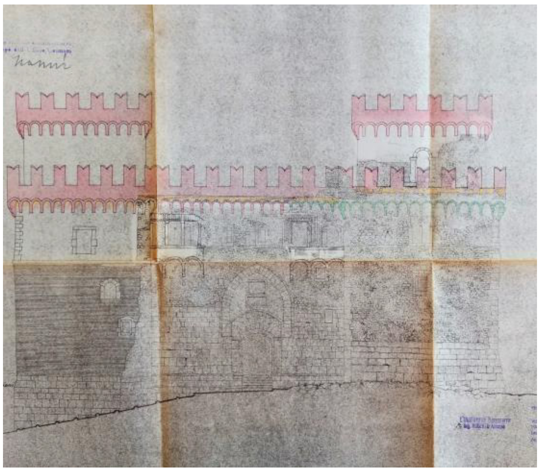
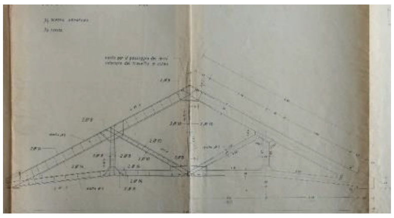
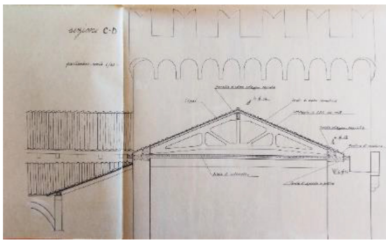


Fig. 3.21
Interior of the Piccolomini Castle of Celano after the bombardments of 1944.







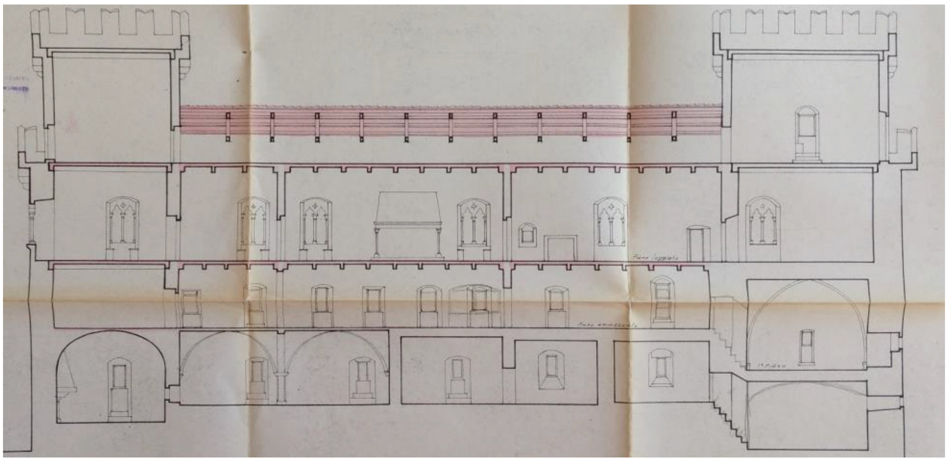


Fig. 3.22 - left
Elevation of the main façade of the Piccolomini Castle. Restoration project (1954, ASGCReg_Az).

Fig. 3.23 – right above
Section drawing of the restoration project. Detail of the truss in reinforced concrete (1954, ASGCReg_Az)

Fig. 3.24 – right below
Section drawing of the restoration project. Detail of the truss in reinforced concrete (1957, ASGCReg_Az)

Fig. 3.25
Section drawing of the restoration project with the elements to be reconstructed.
(1954, ASGCReg_Az)

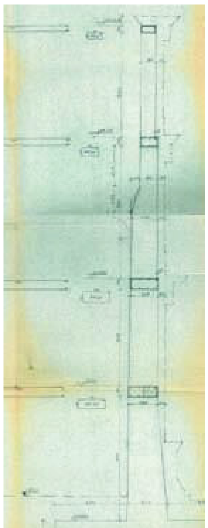


Fig. 3.26 – left
The scaffoldings on the façade of the basilica

Fig. 3.27 – center
Positioning of the steel bars of the top beam.

Fig. 3.28 – right
Section drawing of the reinforced concrete frame of the façade (in which it is possible to see the four orders of bond and top beams)

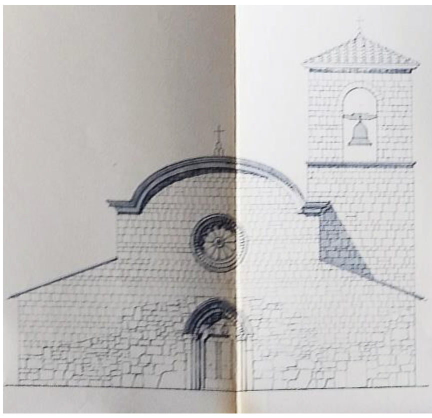
below
Figg. 3.29 – 3.30
Pictures during the survey of the upper part of the façade

Figg. 3.31 – 3.32 – 3.33
Realization of the top beam and connection to the column of the facade: positioning of the connecting bars, positioning of the bond beam bars, pouring of the concrete.

Fig. 3.34
Church of Sant'Orante after the earthquake of 1915.

Fig. 3.35
The church with the provisional structure in timber (front) (1960, (ASGCReg_Az)

Fig. 3.36
The church of Sant'Orante with the provisional structure in timber ("lantern") (1960, ASGCReg_Az)



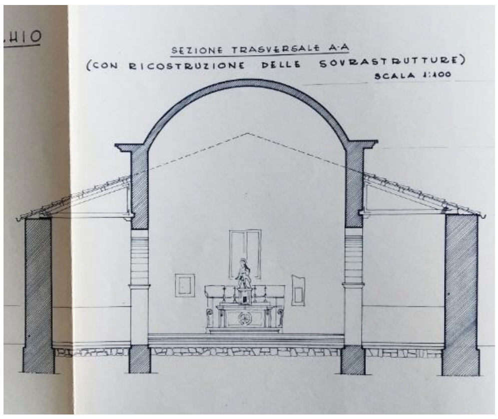
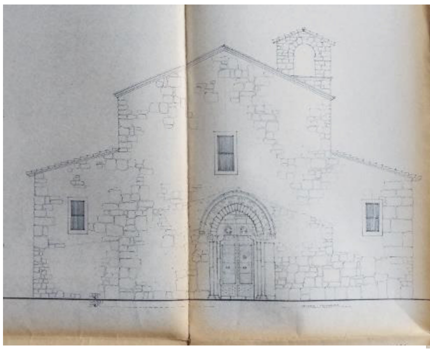


Fig. 3.37 – Fig. 38
Restoration drawings by Delfini and Bevilacqua. Front façade and transversal section. (1960, ASGCReg_Az)



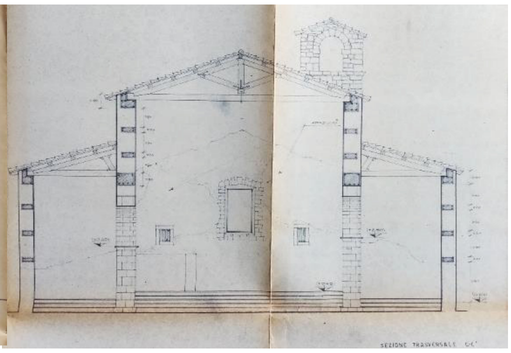


Fig. 3.39 – Fig. 40
Restoration drawings by Galvani and Dander. Front façade and transversal section (1968, ASGCReg_Az)

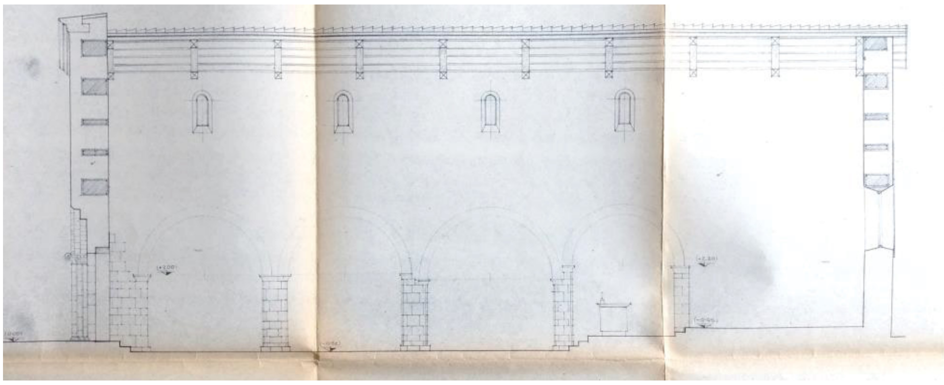
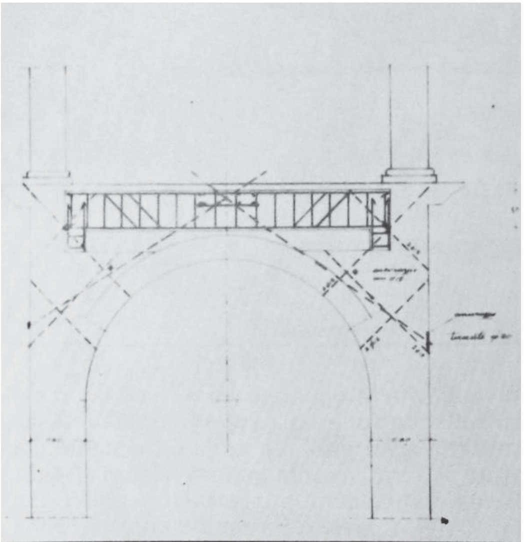


Fig. 3.41
Restoration drawing by Galvani and Dander. Longitudinal section (1968, ASGCReg_Az)



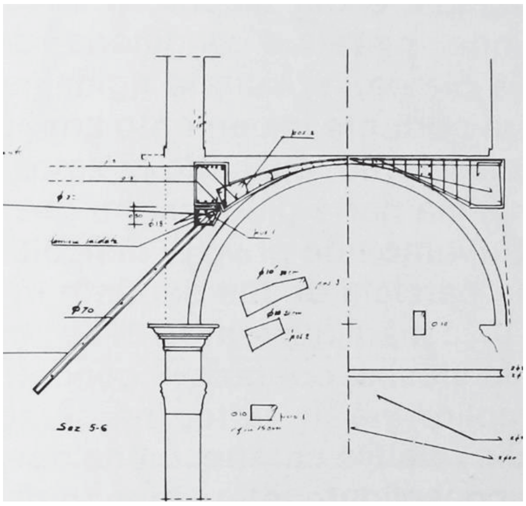


Fig. 3.42 – above left
Section drawing of the reinforcement of the loggia of the first level (1973)

Fig. 3.43 – below left
Section drawing of the reinforcement of the loggia of the second level (1973)

Fig. 3.44 - right
Reinforcement of the ceiling of the apse during the restoration works (1980)

Works from 1970s

As also reported in the first chapter, the other areas of study, such as Lazio, Umbria and Marche were interested by several restoration works with the insertion of reinforced concrete elements only in the Seventy years, because of the happening of other earthquakes.

With the earthquake of Tuscania occurred in 1971, the target of the structural recovery had been reached in the restoration interventions with the use of reinforced concrete elements. In particular, the restoration works pursued by the Soprintendenza between 1971 and 1974 [50] arose the reinforcement of the vaults - with new ones in reinforced concrete placed at the extrados – and the creation of perimetral top beams all along the masonry structures. The restorations of the churches San Pietro (A_4|2, A_4|5) and Santa Maria delle Rose (A_4|6), both of them in Tuscania, Viterbo province, presented these solutions in large part of the interventions.

Instead of Viterbo’s area, after the two earthquakes of Ancona in 1972, Marche presented the necessities of restoration in different cases. One of the most interesting had been pursued in the cathedral of San Ciriaco in Ancona (A_2|3, A_2|8). In this case, the restoration pursued by the Soprintendenza of Marche between 1973 and 1979 [51] aimed to reinforce the church and the bell tower, which presented lot of instabilities and cracks. After the intervention to the foundations, thanks to the insertion of reinforced micropoles, the upper level of the church – at the intersection of the four wings of the buildings – had been interested by the insertion of reinforced concrete beams; the dome also had been reinforced with an auxiliary structure of steel and a base ring of reinforced concrete. Also, other interventions pursued in Marche, as in the Palazzo Ducale in Urbino ((A_2|5), were related to decay conditions, in whose damages the contribution of earthquakes constitute only a little part. The restorations on the Palazzo Ducale, started in 1970, had been interested the steeples, with the insertion of a base ring and the internal “steeples” in reinforced concrete and the reinforcements of the loggias with perimetral tom beams in reinforced concrete –third level – and the insertion of sample reinforced concrete brackets – second level.

Also, in 1984, with the earthquake of San Donato Val di Comino, Frosinone’s province, there were necessary new restoration and recovery interventions in the area of Sulmona, in L’Aquila’s province. Some of the restorations, which interested some of the most important architectures of the area, such as the Badia Morronese (A_1|36) and the church of Annunziata (A_1|37), were pursued, with the direction of Soprintendenza, by the companies Barattelli of L’Aquila and Fondedile S.p.A. of Naples; also in these cases, the role of reinforced concrete had been primary, with the insertions of top beams and micropoles in reinforced concrete [52].

notes

[5] Castanetto, Galadini, 1999.

[6] The damages of the earthquake interested also the areas of L'Aquila, being advertised also in Lazio and the other areas of Abruzzo.

[7] The masonry structure, and especially the ones made with poor mortar, are not able to resist cause the fragile break type of the bricks, the round form of the stones and the different modulus of elasticity of mortar, bricks and stones. Usually, when an earthquake occures, this kind of builings presents usually lots of damages, collapsing of some parts (in particular volts and arches) due to the irregulations of form and materials. With the other and more recent earthquakes qhich hit this area, as L'Aquila in 2009, the behaviour of historic building – withouht any structural reinforcement restoration – was comparable to the ones of the damaged buildings of Marsica.

[8] Ciranna, Montuori, 2016.

[9] In this period, the most important figures who operated in Abruzzo were the Inspector Antonio Munoz, with the collaborations of Gianfranco Vené and Riccardo Biolchi. They surveyed the damaged buildings in the immediate periods after the quakes, then, together with Gavini, provided the restoration works (Trizio, 2017).

[10] Speaking about the risk of earthquakes in Abruzzo and the "calm period" between two following events (Gavini, 1915).

[11] Gavini, 1915.

[12] Gavini, 1923.

[13] Pier Luigi Calore was an intellectual and friend of the Italian poet Gabriele D'Annunzio. His interests in the history and necessary preservation of the Basilica of San Clemente of Casauria were so appreciated to began the social awareness of the building. D'Annunzio, also, defined him as "a small man with strong gestures, who loves a big dead thing and he loves it with all the might of the human passion" (from Ciglia, 2009)

[14] Varagnoli, Pezzi, 2004.

[15] Gavini, 1923.

[16] Gavini, 1926.

[17] In that date, the church suffered a strong earthquake, which stopped the construction works.

[18] Gavini, 1926

[19] Cf. note 1.

[20] The church had been reconstructed after previous eathquake, such as the event of 1706, with a sample facade with three gates and a central rose window.

[21] Divided in three naves, with octagonal pillars and pointed arches of the 13th century, the church presents a simple shack façade in stone. The system of the church, of the 14th and 15th century, had been completely renovated after an earthquake occurred in 1706; the interior presented baroque decorations, with vaults realized in sheet bricks in the lateral naves.

[22] Munoz, 1924.

[23] For other information about Gavini's position in restoration and his works according to the restoration theory, Cf. Pezzi, 2000 and Felli, 2018.

[24] One example can be represented by the work of the engineers Inverardi of L'Aquila, which performed a lot of interventions in the places hit by the earthquake. The engineers became one of the first technicians to use reinforced concrete structures in their project; as for example, the works designed by Riccardo Inverardi for the school of Collemusino, in Pizzoli, near L'Aquila, provided also the use of frames in reinforced concrete and top beams of linking in the existing part to be recovered. The same family of engineers provided for some restoration intervention, such as the one pursued in the Cathedral of L'Aquila, also in this case using the reinforced concrete top solutions (Ciranna et al., 2018).

25 Giovannoni proposed the realization of the frames in reinforced concrete, which constituted the structure of the buiding, reducing the role of masonries only to the architectural form and the covering purposes (Giovannoni, 1917).

26 Donatelli, 2010.

27 Instead of the earthquake of Marsica, of XII degree of damage in Mercalli's scale.

28 The Maiella constitutes a group of mountains in the interior area of Abruzzo, close to the city of Sulmona (L'Aquila province).

29 The church of Santa Lucia in Magliano De' Marsi, L'Aquila province, has built in the 14th century and represent an interesting case study in Abruzzo's architectures. Result of lot of modifications during the time, the church today presents an interior which references to one of the first phases of the church's life. The structure of the church is organized in three different naves, the main bigger than the lateral, with three different gates with decorations, and columns with arches. Only the central nave presents a roofing system with trusses, while the laterals have cross vaults with ribs. The bell tower is external from the structure of the church, positioned in the back side.

30 Munoz, 1915.

31 The engineer Pietrangeli collaborated also in the restoration works of another church of the area. The church of San Giovanni Decollato in Avezzano was serious damaged by the previous earthquake, presenting lot of collapses and fissures. The restoration project, designed in 1937 by Loreto Orlandi and Francesco Pietrangeli, provided the insertion of reinforced concrete top and bond beams, located at different levels, in a way to link the entire reconstructed system (some of the existing masonries were left in the building) (Montuori, 2015; Ciranna, Montuori, 2016).

32 Miarelli Mariani, 1979; Varagnoli Pezzi, 2004; Donatelli (2010).

33 Realized in the period between 14th and 15th century, the castle has a square plan, with four towers at the corners, surrounding the patrol, with elegant and rich double-arched windows. The interior presents an interesting courtyard, with a double order of arches (Munoz, 1915).

34 Also, other defensive architectures of the area, being occupied by German soldiers, were interested by the bombardments during the world, as the Orsini Colonna Castle of Avezzano (Ciranna, 2015)

35 Carried out by the Nicola Cingoli company from Teramo - with structural computations by Riccardo Martegiani and works' direction by Drisaldi Dagoberto (Historic Archive of Genio Civile, Avezzano)

36 Also, some parts of the building were demolished and reconstructed, for example in correspondence of the towers, damaged by the bombardments, and the inside loggia, collapsed with the earthquake of 1915.

37 With the collaboration of other figures inside the Soprintendenza, as the architects Galvani and Dander.

38 Munucipality of Massa D'Albe, in L'Aquila province. The city constitutes the development of different periods, starting from the foundation during the Roman era, as a colony, in the 4th century BC; durgin the medieval ages, the city moved on the close hill, untile theearthquake of 1915, which involved the final movement of the towns in the other close hill. (Montuori, 2016; Felli, 2019).

39 The restoration is specifically analyzed in the following paragraph.

40 The Basilica of San Bernardino represents one of the most important church of the city of L'Aquia; its architecture constitutes the result of the building efforts between the second half of the 15th century and the 1527, in which it had been realized the main façade. The building presents a basilica plans in three different naves, which end in a huge octagonal space, above which there is the great dome. The façade, designed by the architect Cola dell'Amatrice, presents three gates and it is divided into three different orders, with rose windows and pilasters which support the three trabeations.

41 Referring to the intervention pursued by Gavini and Biolchi between 1915 and 1921 (cf. Bartolomucci. 2012).

42 From the relation of the works, from the monograph of Cingoli Company, which had been the firm that carried the works (cf. Cingoli, 1990 and Cingoli, 2009).

[43] After the excepted deassemblation of the façade elements, the façade showed a more dangerous situation, with different disconnection among the elements, a diffuse decay of the masonry and also a failure in the foundations level, beyond the renown cracks. With deeper analysis, which provided also the presence of huge empty spaces in the foundations of the façade, the intervention had been completely modified, aiming to recreate a uniform and massive structure able to balance the lacks of the masonries (Cingoli, 2009).

[44] Report of the restoration project by Nicola Cingoli (Cingoli, 2009).

[45] The church of Sant'Orante, which were serious damaged by the earthquake, presents a Romanic gate and precious frescoes in the interior, which were the only elements survived to the quake (Munoz, 1915).

[46] With the first project by the engineer Delfini and the architect Bevilacqua (Historic Archive of Genio Civile, Avezzano).

[47] Even if the architects found the documentation of the previous state of the building, obtaining also the measures of the original size from the pictures, decided to rebuilt the upper part of the facade differently, removing the last additions of the round crowning (Historic Archive of Genio Civile, Avezzano).

[48] The castle of L'Aquila, commonly reknown as the Spanish fort, founded by the Spanish domintaors in 16th century, suffered a series of damages with the world war II, in which, as the castle of Celano, had been bombed during the german occupation of the city. The restoration works started in 1947, under the direction of Umberto Chierici; the restoration interested the creation of new volumes, with the new spaces for the Soprintendenza, the Museum, the concert hall and an institute for the university of L'Aquila. In this restoration, the role of reinforced concrete is evident in the reinforcement of the underground spaces, obtained at the base level. Furthermore, the new roofing systems had been realized in timber, with perimetral top beam in reinforced concrerete (Chierici, 1951).

[49] The palace of Palena, also called the Castle, is positioned on the highest part of the historic center; founded in the 12th century, it had been continuously modified during times, also according to the natural events. With the earthquake of 1933, the building suffered lot of damages to the structure, with also some collapses; also, as the other castle, the building had been bombed during world war II, collapsing in more parts. The building, before the restoration by Moretti, had been recovered, with the reconstruction of some of the collapsed parts. The company Duilio Miocchi started the restoration works in 1971, concluding the year later, with and the project had been designed by the architect A. Angelini. Aiming to make in safe the entire structure, there were realized top beams in reinforced concrete of the entire building and the base wall at the rock spur had been reinforced.

[50] With the superintendent G. Di Geso.

[51] The superintendents –which follwed in the period of restoration - were the architects Trinci and Polichetti.

[52] Fondedile S.p.A. worked in this period in lot of the interested restoration; in all the cases, the company worked in the insertion of the micropoles, with the patented system of TUBFIX (Historical Private Archive of the Company Barattelli of L'Aquila).

3_2

SIGNIFICANT EXAMPLES

Case studies in L'Aquila and Marsica

The selected interventions represented emblematic case studies, which aim to indicate and show how the use of reinforced concrete developed in the 20th century and also how it is related to the development of the restoration theory. The works on which the research is going to focus on are the interventions occurred in the Basilica of Santa Maria of Collemaggio of L'Aquila (different restorations pursued respectively by Gavini-Biolchi with superintendent Munoz after 1915, and by Genio Civile and by Moretti in the Sixty years) and the church of San Pietro in Albe of Alba Fucens (promoted by Delogu).

Basilica of Santa Maria di Collemaggio

The Basilica of Santa Maria di Collemaggio in L'Aquila [53] had been interested by the earthquake of Avezzano, occurred in January 13th 1915, and suffered diffuse damages to the entire building [54]. The architect Biolchi[55] of the Soprintendenza[56] explained to the superintendent Munoz the situation of the church, and in particular of the façade, after the quake:

> *"The façade of Santa Maria di Collemaggio in its lower left side turned out of the plan of about 25-30 cm, while the upper part turned in, causing a diagonal crack."* [57]

Also, accompanying the description of the damages with a sketch, Biolchi exposed the first efforts with the insertion of auxiliary structures in wood. Some day later, with other aftershock events, the upper part of the façade increased the rotation, going to collapse. According this level of damaged, the superintendent proposed the deassemblation of the interested area [58].

With the beginning of the first world war, the restoration funds were no more available, and the church remained in its precarious conditions till the 1918, in which the Ministry invited the Soprintendenza to design the restoration project [59].

The first phase of the project had been realized by Ignazio Gavini, which in his relations exposed also the state of the church and an analysis of the damages involved by the earthquake:

> *"The façade of Santa Maria of Collemaggio suffered in 1915 the deassemblation of the tying elements, making in danger the entire stability, cause of the lack of links with the system of the church. Since this prototype of façade, typical of L'Aquila's territories, with the horizontal crowning shows all the advantage of an elaborated architectural solution all along the local history, it shows also the flaws due to its nature. These kinds of walls, erected after the built of the churches, lack of continuity with the previous realized parts, and have also large areas free of movement. It had been obvious that the earthquake hit these areas of the building: in Collemaggio, the long oscillations due to the quake produced lot of cracks and overturnings.*
>
> *The Soprintendenza studied a project with the aims of giving to the wall façade the necessity stiffness able to resist to seismic oscillations, able also to connect the entire system with the rest of the church, proposing the insertion of a vertical frame system in reinforced concrete and buttresses in the back side.*
>
> *The system in reinforced concrete is formed by two columns in correspondence of the two longitudinal wall of the church, and two beams, the upper of which extends for the entire façade. To this system, buttresses in reinforced concrete are linked, in a way to join all the structural elements."* [60]

The first version [61] of the project received two rejections by the Genio Civile [62], which involved Gavini to pass the project to the architect Riccardo Biolchi [63], maintaining the purpose of avoiding the deassemblation of the corner pillars of the façade and the view of the reinforced concrete frame.

The new version of the restoration, released in June 5th 1919 had been approved, thanks also the required integrations, with the specifications about the insertion of the new masonry and the link systems with the existing structure. The restoration works finished at the beginning of 1921 (A_1|1).

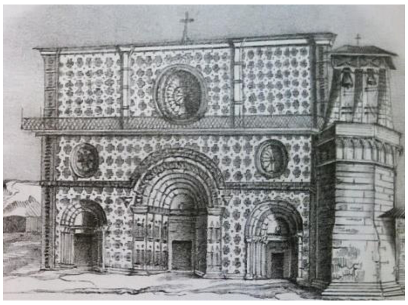
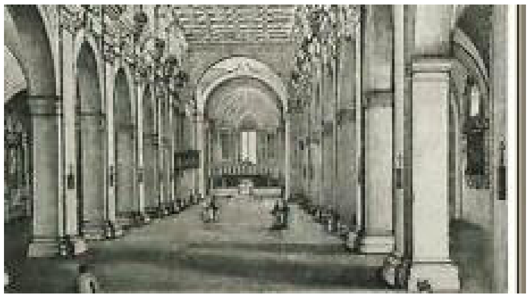



Fig. 3.45 – left
The façade of Collemaggio in 1880-1885 in a drawing by Leosini.

Fig. 3.46 – right
Interior of Collemaggio in 1890 from a postcard.

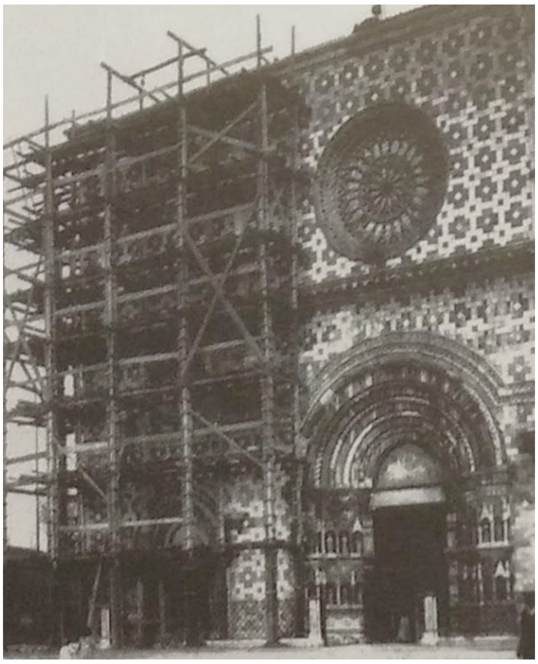
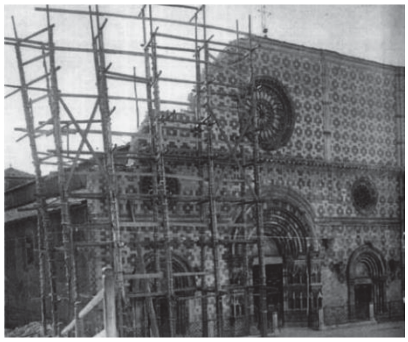
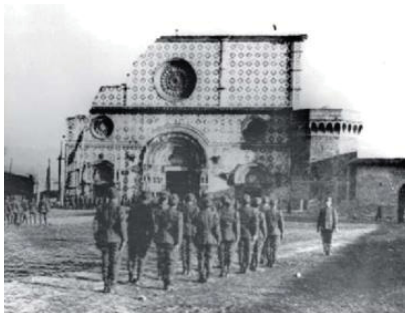




Fig. 3.47 – left
The façade of Collemaggio during the deassemblation works of 1915. (ASSA)

Fig. 3.48 – right above
The façade of Collemaggio after the deassemblation of 1915. (ASSA)

Fig. 3.49 – right below
The façade after the deassemblation (1915-1920).

"First of all, the reconstruction of the frontal wall is pursued with new elements in brick, packed and hollowed, instead stones, unloading the structure and bringing the center of gravity in a lower position. The new masonry will be posed regularly, with elements of connection with the existing part. […] The new masonry will be reinforced with an internal reinforced concrete frame; these new elements are designed also to bring to the back buttresses. […] Aiming to reinforce also the corner resistance, a new buttress is designed behind the reinforced concrete column, with a couple of steel ties for limiting the push stresses. Other two small buttresses are designed at the intersection of the façade with the longitudinal interior walls of the main nave. […] The realization of the concrete elements will be done with wood packing left in the masonry after the works." [64]

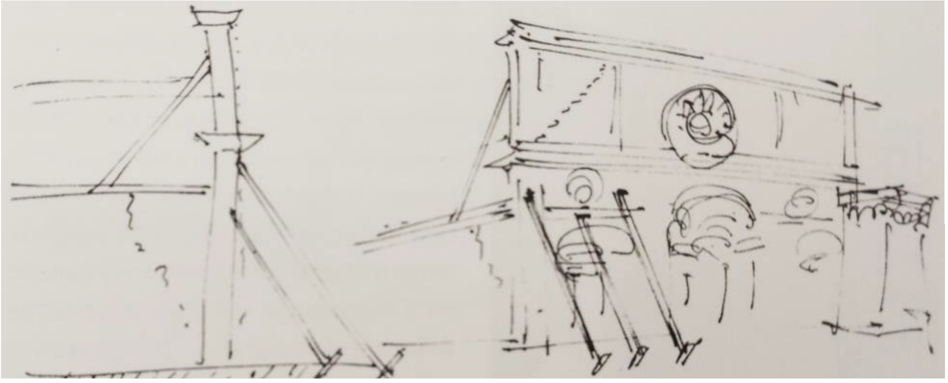
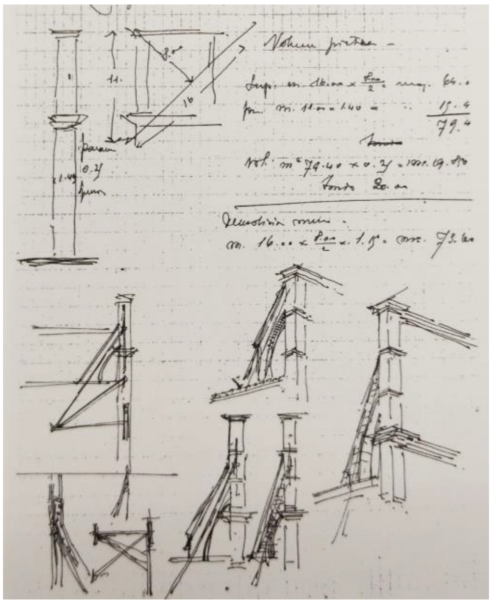


Fig. 3.50
Sketches by Biolchi showing the damages of the façade and the provisional structures. (ASSA)



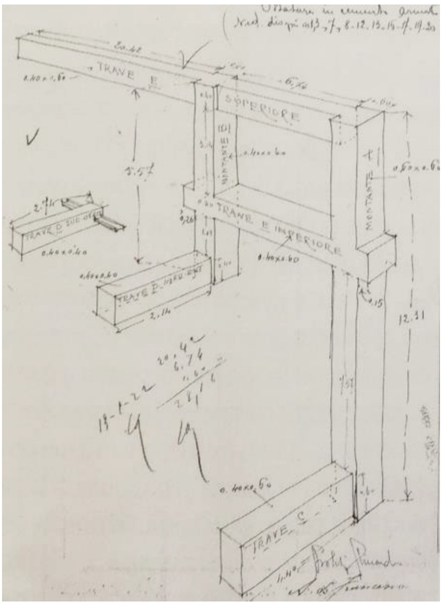


Fig. 3.51 – left
Sketches of the structural reinforcement by Biolchi (ASSA)

Fig. 3.52 – right
Scheme of the reinforced concrete frame of the façade (ACS)

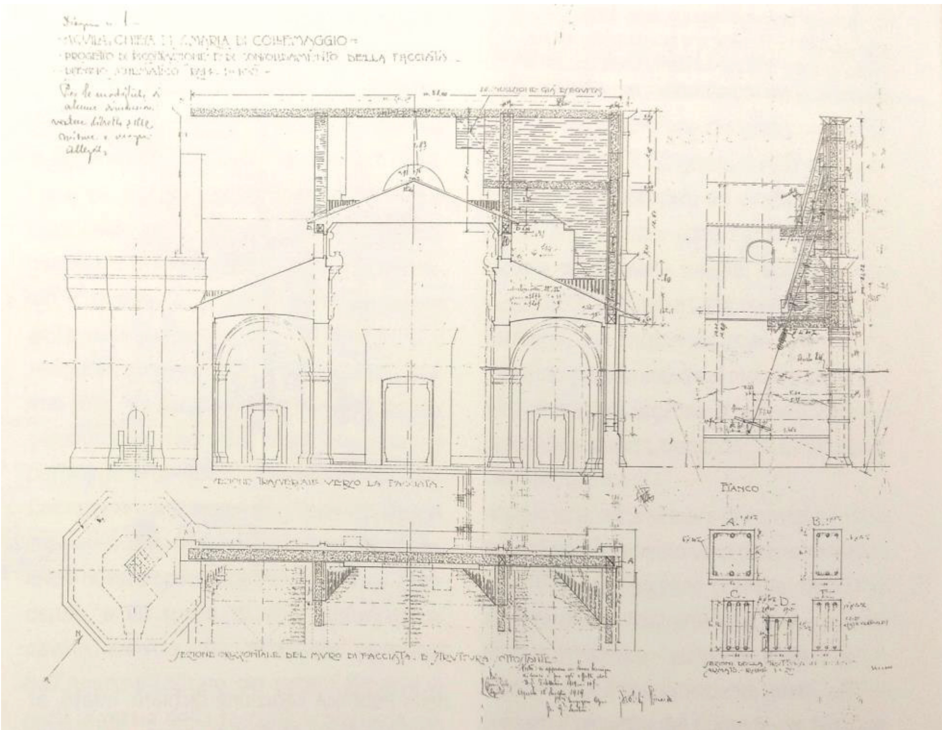


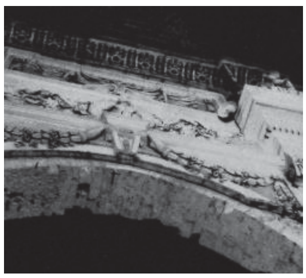
Fig. 3.53
Transversal section drawing of the restoration project by Biolchi (ASSA).

Collemaggio, after the first intervention, had been interested by other two different interventions in the late Sixty to the first years of the Seventy period, in which the Genio Civile, firstly, and the Superintendent Moretti, secondly, found to operate [65].

After years of continuing decay of the structures, some of them after a local earthquake occurred in 1958, the Genio Civile proposed the demolition and the reconstruction of the dome, in incipient collapse (A_1|12). In this phase, from 1960 to 1962, the new element had been reconstructed completely in reinforced concrete, as also the new top perimetral beams. In particular, there were inserted two levels of beams in reinforced concrete (base beam and horizontal beam at mid height [66]). In the Seventies, the debated restoration pursued by Mario Moretti aimed to redefine the "supposed" original aspect of the basilica [67], removing the baroque decorations and the ceiling coffer of the main nave, giving back the "clean surfaces of the medieval walls" [68]. The work by Moretti interested also the some structural elements of the church, letting the reopening of the rose window of the façade [69], the recreation of two columns in the intersection among the main nave and the transept, rebuilt in masonry [70], and also the raisings of the walls [71] (A_1|29).

Fig. 3.54
Interior of Collemaggio before the intervention of Moretti.

Fig. 3.55 – 3.56 – 3.57
Interior of Collemaggio before the intervention of Moretti. Details of the removal of the baroque stuccos.



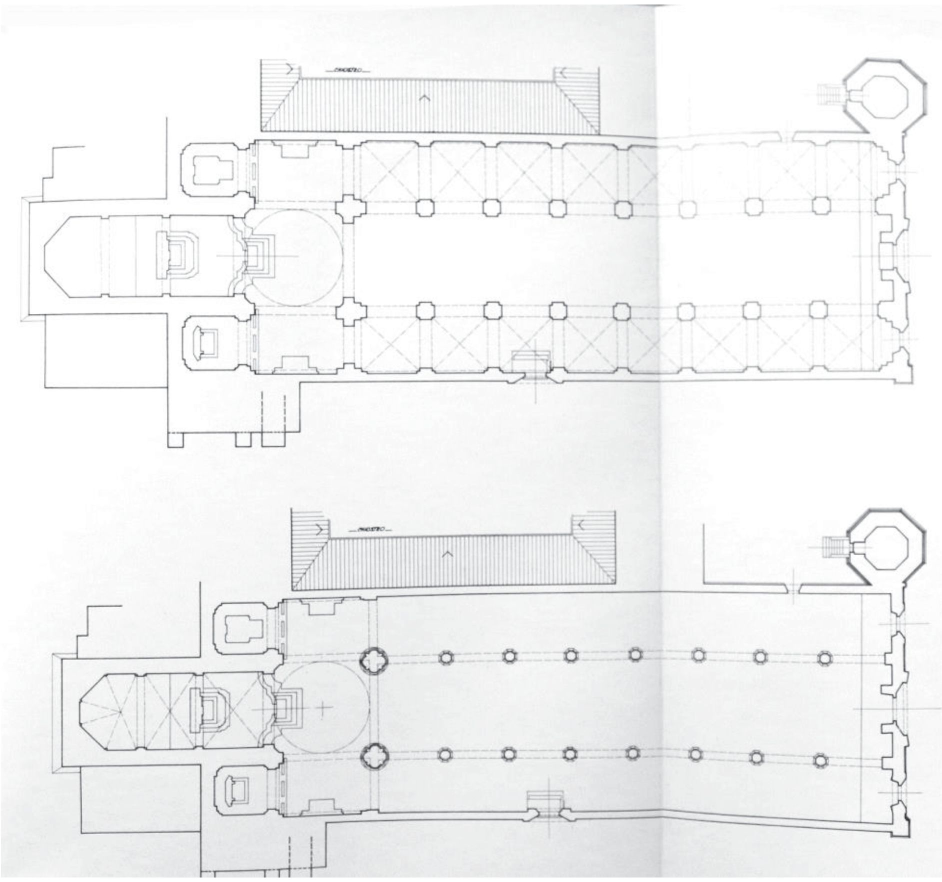


Fig. 3.58
Comparison plans between the previous version of Collemaggio and the new one after Moretti's intervention

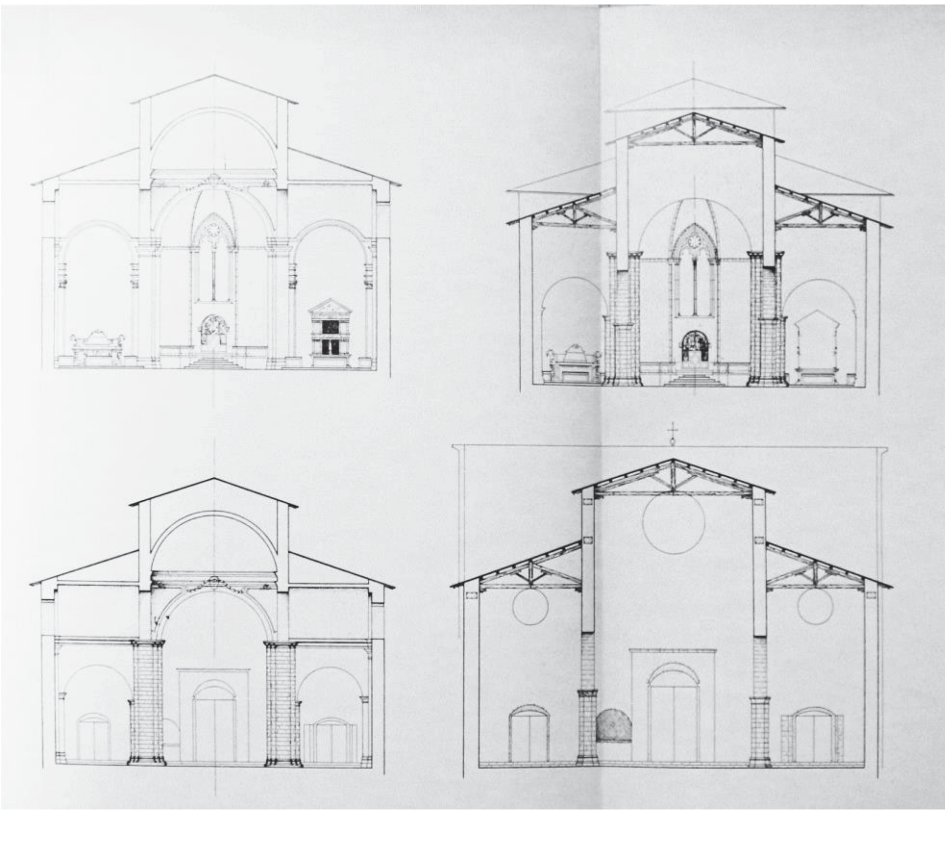


Fig. 3.59
Comparison transversal sections in both directions between the old (left) and new (right) versions of Collemaggio

Differently from Collemaggio, the restoration project pursued for the church of San Pietro in Albe received approvals also from the most important figures in the national restoration field.

Church of San Pietro in Albe

The church of San Pietro, located in Massa D'Albe [72] suffered large damages with the destroying earthquake of 1915, such as also the superintendent Munoz[73], describing the monuments of Abruzzo hit by quake, wrote only broken words:

> *"Today the church is completely in ruin conditions: the grooved columns are broken, the iconostasis reduced in pieces, the lateral walls are going to collapse; only the ambon left entirely among all these destructions; the aisle had been conserved only for only two meters of height."* [74]

The scenario of the church was dramatic: the roof, the vaults and the wood trusses completely collapsed, parts of the perimetral walls, part of the façade and of the bell tower, together with the Corinthians columns of the iconostasis and ciborium, went to collapse. The southern wall, thanks to the buttress elements in the convento's side, had few damages; also the aisle collapsed for half of its height and the northern wall must be demolished because of the incipient collapse.

The restoration works, since the beginning, appeared complex and hard to be execute. The first step consisted in the deassemblation of the squared stones of the northern wall and aisle, being also catalogued, numbered, and piled methodically; the same method had been used for the survived columns, numbering the single composing elements and the capitals. There were built provisional roofs for protect the ambon, the iconostasis and the frescoes. For forty years, all the pieces remained in this situation, waiting for the restorations.

This first work of deassemblation and cataloguing of the elements constituted an important starting point for the following restoration, performed between the 1955 and 1957 with the direction of the superintendent Raffaello Delogu [75] (A_1|9). Apart the cataloguing of the elements, the base of the restoration constituted also in the historic research and the photographical documentation of the state previous and after the earthquake.

The restoration reject had been based on the removing of the 18th century additions, leaving the building to the Romanesque aspect, and, in particular, on the use of reinforced concrete.

Also Gavini suggested the use of the modern technology:

> *"The earthquake of 1915 reduced the church in a mount of ruins, and the State wants to wait better days for restoring this building, which is one of the most precious artwork of Italy. And this is will be*

possible and deserving of our society only when the modern techniques will be used in a way to ward off all these disasters." [76]

The project provided for the insertion of a continuous frame in reinforced concrete in the entire structure of the church, including also the roof system and the foundations, creating a "cage" able to resist to quake stresses. The executive phase of the restoration site started with the deassemblation also of the floor, whose elements had been numbered and catalogued, for reinforcing the foundation level and creating the plinth of each concrete column [77].

The elements and the capitols of each column were remounted by anastylosis, after the insertion of steel bars with concrete in the nucleus of the structural element, made linked to the ground thanks to the plinth reinforcement bars. In the upper part, the reinforcement of the columns had been linked also with the beams in reinforced concrete, making the upper part of the frames. Also, the top beam of the bell tower and of the aisle were realized at the same height, in a way to connect all the elements.

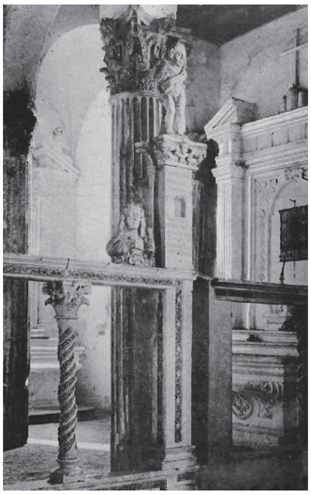


Fig. 3.60 - left
The church of San Pietro in Albe before the earthquake of 1915.

Fig. 3.61 – right
Interior of the church of San Pietro. Detail of the iconostasis.

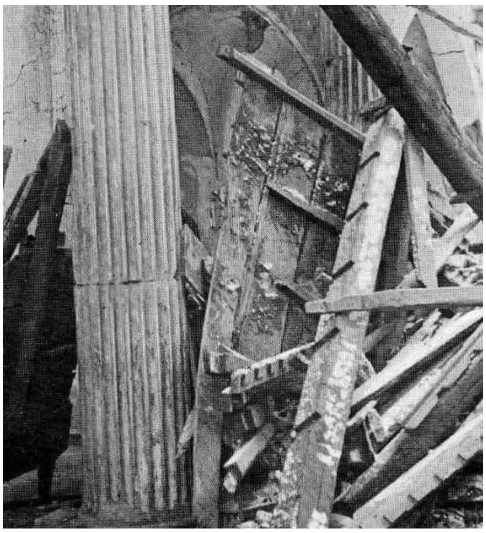


Fig. 3.62 – left
Interior of the church of San Pietro in Albe after the earthquake of 1915.

Fig. 3.63
Interior of the church of San Pietro in Albe after the earthquake of 1915; first phase of the interior's liberation from the ruins.

Fig. 3.64
View of the apse collapsed with the earthquake.

Fig. 3.65
Interior of the church of San Pietro in Albe during the first phase of liberation from the ruins.

Fig. 3.66 - left
Interior of the church of San Pietro in Albe during the first phase of liberation from the ruins. Detail of the ambon.

Fig. 3.67 – right
Interior of the church of San Pietro in Albe after the liberation from the ruins.

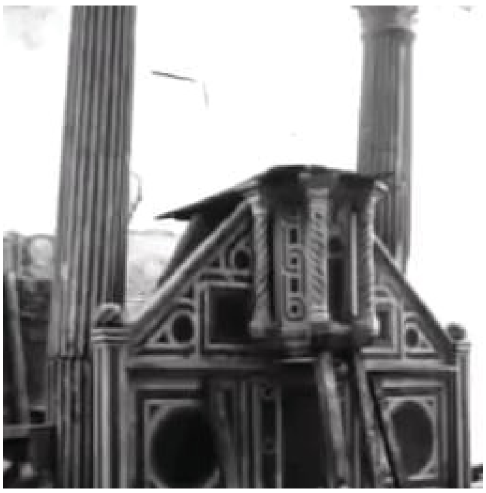


Fig. 3.68 – Fig. 3.69
Workers during the deassemblation of the elements and the cataloguing.

Fig. 3.70
View of the main gate of the church after the liberation of the interior from the ruins.

Fig. 3.71
The interior of the church after the liberation.

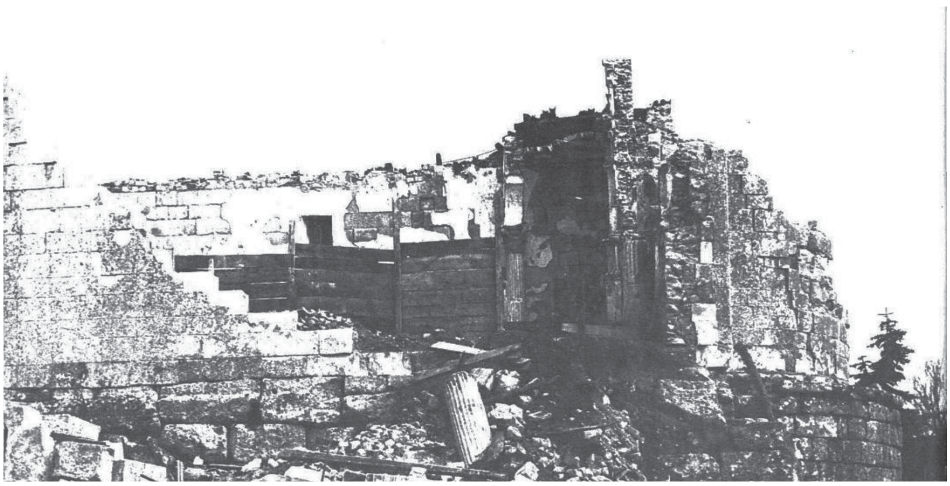


Fig. 3.72
View of the apse after the removing of the decaying elements.

Fig. 3.73
The disassembled elements of the church

Fig. 3.74 - left
The columns before be punctured for the insertion of reinforcement bars.

Fig. 3.75 – right
The columns during the puncture for the insertion of the steel bars.

Fig. 3.76
Axonometric restitution of the new reinforced concrete structure.

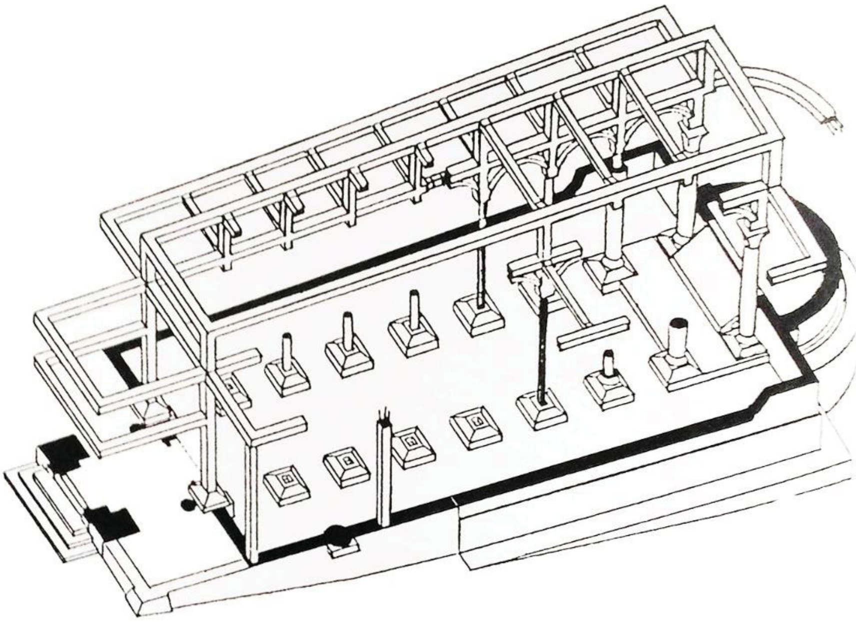
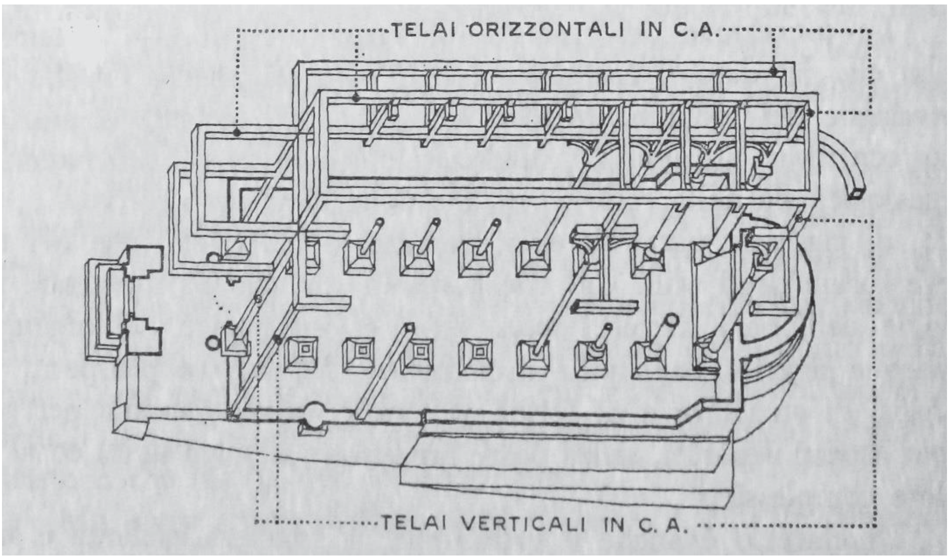


Fig. 5.77
Axonometric restitution of the new reinforced concrete structure, with the identification of horizontal and vertical frames.



The collapsed walls had been reconstructed with new elements able to recognize the additions to the existing elements.

The final result had been celebrated also by Cesare Brandi, defying the pursued the restoration as "a dismaying puzzle solved for the love of the art" [78] :

> *"The recent restoration of the church of San Pietro conducts us to the happier and simpler thoughts: it is indeed the best completed monumental restoration in the Italian postwar […] and because it had been also one the hardest, it needs to be reported as a reference.*
>
> *We need it.*
>
> *Never, as in this postwar period, the restoration of monuments reached so much low levels, according to the strictness, critic probity, historic respect, also in comparison with the 19th century actions.*
>
> *The destruction of the bombardments, involving the regrets, forced the interventions everywhere, so also now this phase of copies of buildings, in the highest consideration of these works, is not finished yet. [..]*
>
> *So this is why, with this spreading restoration/falsification, what done in Alba Fucens shines as the peak of Monte Velino [79] , even if it is also a work of indisputable mastery. Indeed, it represents a very rare case. […]*
>
> *But what method did have to be used in this enormous puzzle of stones in so high risk seismic zone? We need to think that we were in front of a group of disassembled stones, and that the criteria of saving all the historic phases could be influenced by the will of the simple reconstruction. […] The method pursued by Delogu had been linear and inflexible."*[80]

Fig. 3.78
Article in the *Corriere della sera* by Cesare Brandi in 1957 (ASD.Corriere)

Uno sgomentante "puzzle,, risolto per amore dell'arte

La ricomposizione della insigne chiesa di San Pietro ad Alba Fucense, sbriciolata dal terremoto d'Avezzano, è un ammirevole esempio di scrupolo storico, di rispetto per il passato e di valentia tecnica

Roma, dicembre.

Non saranno molti a sapere dove si trovi un luogo dal nome così suggestivo come Alba Fucense; e si dice luogo, perchè la città antica, a cui il nome corrispondeva, è scomparsa da un pezzo, e di quella medioevale ben poche sono le rovine, seppure quanto mai romantiche, sull'alto cocuzzolo. Ma questa peregrina località che, per gli scavi condotti nel sito della città romana, è soprattutto per il restauro felicissimo della chiesa di San Pietro, diverrà perfino una mèta turistica, non è neppure di difficile accesso: a pochi chilometri da Avezzano, in due ore si raggiunge da Roma.

Il luogo è di una grandiosità naturale e illimitata: forse da nessun altro posto è possibile vedere vicinissimo un monte così alto e grande come il Velino: parte dal suolo diritto come un muro. Intorno, la catena del Sirente, a grandi falcate, ricinge pianori fitti di mandorli; quasi al centro spicca (e siamo a più di mille metri) il colle su cui sorgono la chiesa di San Pietro e le rovine di Alba. E' un luogo, oltre che splendido, fatidico: nella piana che si svolge sotto al colle di San Pietro, avvennero la rotta di Corradino e l'infausta vittoria di Carlo d'Angiò. In quella valle severa, il Sacro romano impero su base italiana cadeva per sempre: fra le tante sciagure del nostro Paese, non fu certo la minore. Stando sulla terrazza che, con l'attuale restauro, è stata creata a tergo dell'abside, si vede, nella piana, un ciuffo d'alberi: là si trovava Santa Maria della Vittoria che Carlo d'Angiò si affrettò a costruire, proprio dove Corradino perse la battaglia e la rovina del Mezzogiorno cominciò.

Il restauro recentissimo della chiesa di San Pietro ci conduce a pensieri più lieti seppure più modesti. Si tratta infatti del restauro monumentale di gran lunga il migliore che sia stato compiuto nel dopoguerra in Italia, e poichè investiva un caso, che più difficile non poteva darsi, vale davvero segnalarlo come esempio. Ce n'è bisogno. Mai, come in questo dopoguerra, il restauro dei monumenti aveva segnato punte così basse, in quanto a rigore, probità critica, rispetto storico, anche riguardo ai tempi di frenetici ripristini ottocenteschi.

La distruzione dei bombardamenti, scatenando i rimpianti, ha finito per forzare, un po' ovunque, la mano; sicchè ancora non è finita la serie dei restauri che non sono restauri, ma, nella migliore delle ipotesi, copie, non so quanto auspicabili o ammissibili, del monumento perduto. E' di ieri lo scempio della ricostruzione del ponte di Pavia, tanto per fare un esempio; è ancora in costruzione il ponte a Santa Trinita a Firenze, che poteva e doveva essere ricostruito ripescando le pietre cadute e rimaste nel fiume, mentre è stato rifatto tutto di nuovo.

Difficile restauro

Sicchè non possiamo scandalizzarci, noi italiani, se andando a Colonia, troviamo le chiese medioevali, le famose e pressochè distrutte chiese di San Gereone, di Santa Maria in Campidoglio, dei Santi Apostoli; ricostruite «come erano», e senza neppure una data o un segno divisorio fra il tanto nuovo e il poco vecchio.

Ecco perchè allora, con questo dilagante restauro-falsificazione, quanto è stato fatto ad Alba Fucense, seppure avrebbe figurato sempre come opera di indiscutibile magistero, splende ora come la vetta del Velino coperta di neve.

Si tratta, infatti, di un caso, se non unico, rarissimo. Già tempio etrusco-italico del III secolo, che, per le vestigia ancora superstiti, già di per sè sarebbe un resto incalcolabile, divenne chiesa cristiana almeno nel VI secolo, abbazia benedettina nel XII. Le trasformazioni — che contarono fra l'altro la suddivisione in tre navate, con l'impiego di magnifiche colonne adrianee — non furono tali da cancellare l'antico tempio. Degli ornamenti, che resero questa chiesa un museo, i più appariscenti furono quelli cosmateschi, pulpito e iconostasi. Ma la tregenda dei terremoti, iniziatasi già nel secolo XII, si concluse con quello, definitivo, del 1915 che distrusse Avezzano.

Rimasero in piedi il muro di sinistra, parte del muro di destra, parte dell'abside: le fotografie del tempo mostrano l'interno ancor più come dopo un bombardamento che dopo un terremoto. Iniziatosi subito l'inevitabile smontaggio delle parti pericolanti e delle colonne, il restauro, che era quello tipico di *ricomposizione* o *anastilosi*, si dimostrò subito così difficile e carico di incognite, anche nelle direttive da seguire, che le pietre furono seppellite in una trincea lungo la chiesa, e, fatte le fotografie indispensabili, il monumento fu abbandonato. Come distrutto lo davano tutte le guide. Ma non era distrutto al punto di non potere risuscitare: le splendide opere cosmatesche della iconostasi e del pergamo restavano; restavano le colonne e i capitelli, le pietre tutte delle antiche mura della cella e dell'abside, per fortuna seppellite e sottratte alla dispersione.

Ma quale il criterio da seguire in questo enorme *puzzle* di pietrami, e, soprattutto, in una zona sismica come quella; quale il criterio da tenere, riguardo alle fasi succedutesi nella storia del monumento? Bisogna pensare che si era di fronte a un insieme di pietre sgretolate, e che il criterio di salvaguardare le fasi storiche poteva sembrare viziato dal fatto che queste fasi non andavano ormai *rispettate*, ma anch'esse *ricostruite*. Da siffatta constatazione alla tentazione di fare piazza pulita del Medioevo e di limitarsi a liberare le reliquie del tempio etrusco-italico, il passo era breve, brevissimo: ma quanto fallace. Nè il soprintendente Delogu compì qualcosa di simile. Ma il criterio a cui si attenne fu lineare e inflessibile.

Le colonne svuotate

In primo luogo si preoccupò di dotare la chiesa di una struttura indeformabile e invisibile di cemento armato: e, una volta assicurata la statica, tenuto conto della zona, ricomporre la chiesa medioevale nello stato in cui lo consentivano gli elementi superflui rispetto alla sua storia, fino almeno alla ultima sistemazione cosmatesca. Ripristinare anche l'altare settecentesco sarebbe stato scrupolo eccessivo, in quanto che si era trattato di una aggiunta provinciale e del tutto occlusiva rispetto alla struttura spaziale della chiesa benedettina, che poteva essere riconquistata in pieno. E tuttavia, anche delle fasi storiche successive al secolo XIII, sono state lasciate tracce evidenti, come l'arco gotico della cappella all'ingresso, e l'iconostasi cosmatesca, dove fu spostata nel Settecento: ciò che ha dato modo di documentare una fase, che non si doveva cancellare, anche se non era obbligatorio conservarla, della storia del monumento.

Ma per tornare alla struttura antisismica della chiesa, questa è stata raggiunta svuotando internamente le colonne, con un accorto uso del filo elicoidale, sicchè non sono ormai più che la guaina esterna di una struttura solidissima di cemento armato, affogata nel resto della muratura come le ossa dentro i muscoli. Una gabbia potente lega così colonne e pavimento, soffitto e pareti, abside e campanile. L'aspetto non è alterato affatto, e vedendo la bellissima, intatta epidermide delle colonne si resta quasi increduli che siano state vuotate come canne d'organo. Ma qualsiasi scrupolo relativo alla integrità interna delle colonne sarebbe stato senza giustificazione: l'intangibilità della materia di cui consta un'opera d'arte — sia questa una colonna o una pittura — vale solo fino al punto in cui un'alterazione della materia diviene, a vista, una alterazione dell'immagine. Per le colonne di San Pietro, come per qualsiasi colonna, quel che conta è la forma, la lavorazione, il colore e la trasparenza del marmo all'esterno, non già l'interno del fusto.

Il fine ultimo è la conservazione di un monumento e non la feticistica intangibilità della materia. E questo è stato raggiunto con una perfezione mirabile. Che dire poi della ricomposizione dell'abside e delle mura perimetrali, eseguita studiando concio per concio e riconoscendoli sulle fotografie? Il risultato dà l'opera come assolutamente integra e come fosse passata intatta attraverso il tempo; senza il minimo falso, e senza ingombri ortopedici di catene, sostegni, rattoppi, poichè tutto è celato dentro la muratura. Così si è contemperato il principio statico con le esigenze del restauro più onesto e severo.

Nel convento attiguo, se la Cassa del Mezzogiorno darà i fondi (farà bene a darli), sorgerà il museo dei resti medioevali e degli insigni reperti classici. Ma anche un'ampia e moderna foresteria con un luogo di ristoro. San Pietro potrà divenire, in quella posizione regale, e con quell'aria montanina, una stazione obbligata per un giro in una regione prossima a Roma e poco nota, che per altro dirama in paesaggi sorprendenti e offre monumenti singolarissimi. Chè se poi ci si riporteranno le venerande porte lignee scolpite del secolo XII, che ora stanno all'Aquila, il trittico famoso e la Stauroteca, che ora sono a Palazzo Venezia, la Venere classica che si trova a Chieti, non è troppo dire che il museo, piccolo ma preziosissimo, sarà fatto. Nessuno dovrebbe dolersene.

Cesare Brandi

notes

[53] The Basilica of Santa Maria di Collemaggio had been commissioned by Pietro da Morrone – Pope Celestinus the Fifth – in 1287; the building presents a simple structure, with three different naves, separated by a system of polygonal section pillars, a transept which divide the church from the aipse. The façade with horizontal crowning started to be realized in the 14th century and completed in the century after; it presents three different rose windows. (Bartolomucci, 2004; Varagnoli, Pezzi, 2004).

[54] Bartolomucci, 2015.

[55] The architect Riccardo Biolchi had been one of the most important figure in the efforts of cultural preservation of Abruzzo. Born in Rome in May 2nd 1880, he is registered in the order of architects for the L'Aquila's province since 1923, even if his studio was located in Rome (Annuario Ordine Architetti, 1930). Inside the Soprintendenza since the first years of the Twentieth Century, together with Gavini he worked for the Soprintendenza in the area of Marsica from 1915.

[56] In 1924, the Soprintendenza all'Arte Medievale e Moderna for the Abruzzo had been established. Before, the control authority for the cultural heritage had been the Soprintendenza of Rome. The first two head of the authorities were Gianfranco Vené and, since the 1928, Riccardo Biolchi himself. (Donatelli, 2010).

[57] Letter of January 19th 1915 (from Bartolomucci, 2004).

[58] The project of the disassemblation of the façade had been carried by the architect Biolchi and took several time before the execution, because of the occupation of the basilica by the soldiers and the different responsibility in the works between the Municipality of L'Aquila and the Soprintendenza.

[59] Lecter of December 26th 1918 from the Minister of the *Pubblica Istruzione* wrote to the Superintendent: *"This Ministry […] allow your office to design the project for the reconstruction of the façade"* (from Bartolomucci, 2004).

[60] Gavini, 1923.

[61] The first version of the project had been denied because of the necessity of reinforce the rebuilt masonry and link it to the existing system.

[62] The authority of structural evaluations on projects.

[63] Bartolomucci, 2004.

[64] Relation of the project by Biolchi, 1919 (Ibidem).

[65] Bartolomucci, 2004.

[66] From the Report of the works (Ibidem).

[67] Bartolomucci, 2016.

[68] This disseration does not intend to lend about the propriety of the restoration pursued by Moretti, trying only to analyze the use of reinforced concrete in the intervention.

[69] The rose window was walled, maybe due to static resolution.

[70] The reconstruction of the elements in masonry instead reinforced concrete can be confirmed also with the damages that the church suffered with the recent earthquak of 2009 (Cf. chapter 5).

[71] For the lateral walls the height difference became 3.15 m, while for the central wall 3.65 m.

[72] Built on the ruins of the Apollo's temple, the church was a paleochristian basilica since the sixth century AD, and later it belonged to the Montecassino's order. The church, mentioned for the first time under the name of "Pietro in Alba", begun to be part of the Diocesis of Marsi since 1115, while in the twelfth century some modification works were commissioned by the benedictin abbot. The modifications provided probably the actual plant of the building, with the creation of a new aisle with the crypt and the three naves, reusing Corinthian columns. In the center of the main façade, according to Delogu, a bell tower was positioned (while Gavini asserted the presence of a three naves nartex, connecte to the hall of the church by three gates). The church suffered at least two destroying earthquake before the event of 1915 (from Soprintendenza, 1991).

[73] The superintendent Munoz gave a description of all the monumental building which were damaged by the earthquake (Munoz, 1915).

[74] Munoz, monuments hit by the earthquake, 1915.

[75] With the collaboration of Augusto Angelini, Fulvio Panella and Sirio Ferri, with the company Augusto Stinellis, frescoes restoration by Enrico Vivio.

[76] Gavini,1923.

[77] During this phase, also there were discovered some elements of the preexisting structures and also of the roman temple. [78] Corriere della sera, December 27th 1957.

[79] Monte Velino is the mountain close to Alba Fucens and the northen areas of Fucino.

[80] Ibidem.

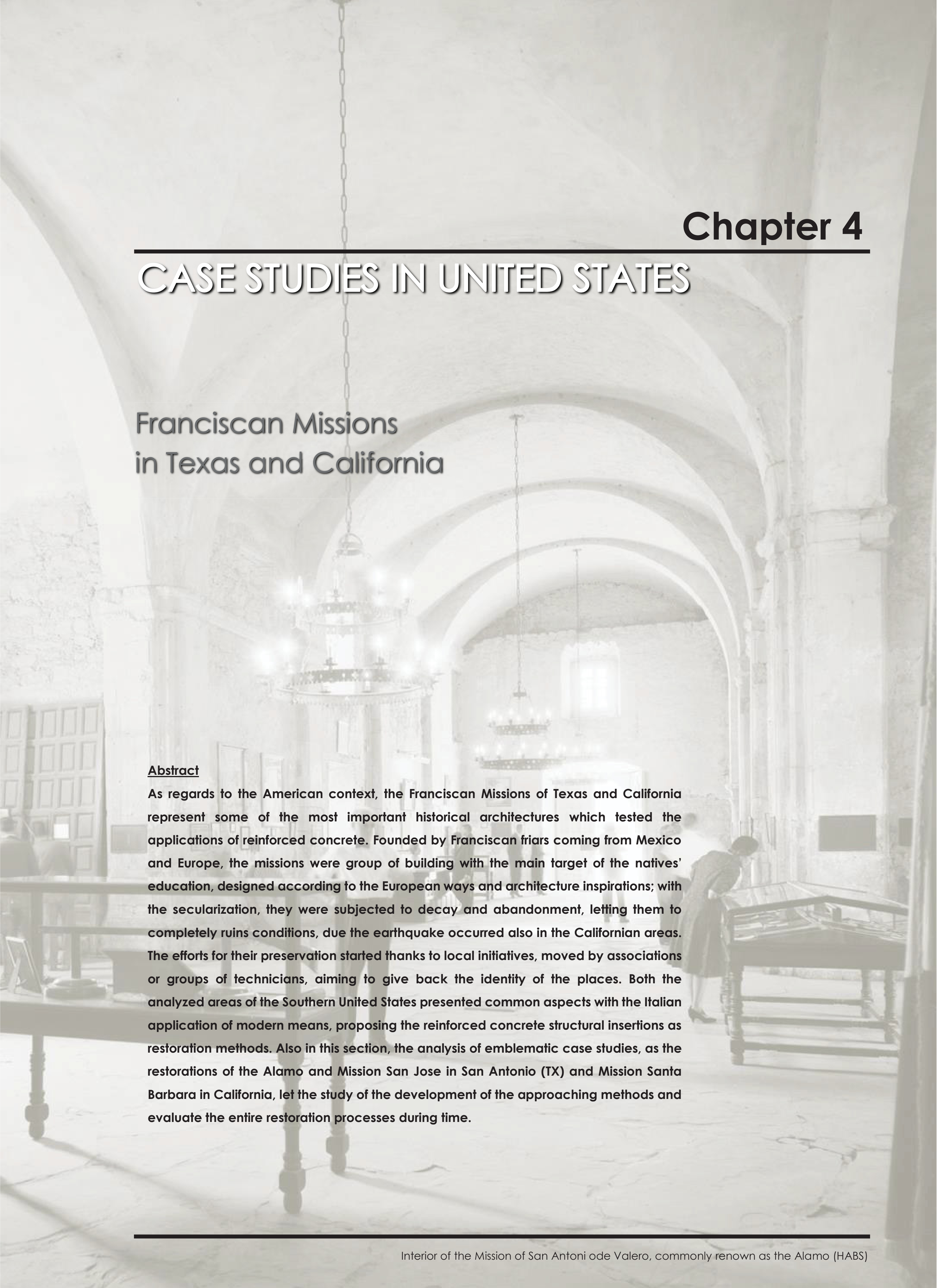
Chapter 4

CASE STUDIES IN UNITED STATES

Franciscan Missions in Texas and California

Abstract

As regards to the American context, the Franciscan Missions of Texas and California represent some of the most important historical architectures which tested the applications of reinforced concrete. Founded by Franciscan friars coming from Mexico and Europe, the missions were group of building with the main target of the natives' education, designed according to the European ways and architecture inspirations; with the secularization, they were subjected to decay and abandonment, letting them to completely ruins conditions, due the earthquake occurred also in the Californian areas. The efforts for their preservation started thanks to local initiatives, moved by associations or groups of technicians, aiming to give back the identity of the places. Both the analyzed areas of the Southern United States presented common aspects with the Italian application of modern means, proposing the reinforced concrete structural insertions as restoration methods. Also in this section, the analysis of emblematic case studies, as the restorations of the Alamo and Mission San Jose in San Antonio (TX) and Mission Santa Barbara in California, let the study of the development of the approaching methods and evaluate the entire restoration processes during time.



Interior of the Mission of San Antoni ode Valero, commonly renown as the Alamo (HABS)

Capitolo 4

CASI STUDIO NEGLI STATI UNITI

Le missioni francescane in Texas e California

<u>Abstract</u>

Per quanto concerne il contesto americano, le missioni francescane del Texas e della California costituiscono alcuni tra gli esempi più rinomati di edifici monumentali restaurati mediante l'inserimento di strutture in calcestruzzo armato. Fondate dai frati francescani proveniente dal Messico o dall'Europa, le missioni nascono come un insieme di edifici dalle diverse funzioni, fulcro di cui era la chiesa, con l'intento di educare le popolazioni native alla società occidentale, e vengono ideate prendendo spunto dalla tradizione architettonica e formale europea. Con la secolarizzazione, e il richiamo dei frati nei luoghi di origine, gli edifici vengono via via abbandonati, lasciati all'incuria e ai fenomeni naturali, quali i terremoti nelle aree californiane, che le portano a stato di rudere. Le prime iniziative per la loro conservazione sono di carattere locale, grazie a associazioni o gruppi di ingegneri, con l'obiettivo di ripristinare anche l'identità persa dei luoghi. Entrambe le aree di studio presentano aspetti comuni con il contesto italiano nella proposizione di inserimenti di elementi in calcestruzzo armato. Come nel contesto precedente, l'analisi di casi di studio emblematici, quali l'Alamo e la missione di San José in San Antonio (Texas) e la missione di Santa Barbara in California, permettono di approfondire l'evoluzione delle metodologie operative sul costruito storico, fornendo un quadro conoscitivo più approfondito e completo degli interventi di restauro.

Introduction

While the previous chapter focuses on the restoration works pursued in Italy, this part of the dissertation aims to analyze the American area. United States represent an area in which the European architectures and the preservation theories influenced radically the entire context. As consequence, the interested areas of study, such as California and Texas, present strategies and approaches to the constructions that can be compared with some sample in Europe, and also in Italy.

The study on these areas is related to different and specific reasons, in which the use of reinforced concrete, after the first evaluations of its use in the new constructions, started to be considered also as a recovery technique in the structural recovery and improving. In particular, among the monumental buildings which were interested by a series of preservation interventions, the most arresting restoration works were applied on the Franciscan missions.

The beginning of Franciscan missions in the United States can be found in the movements of Spanish conquerors in the eighteenth century, during the colonial period. Although the major objective was to spread Christianity among the new world, the missions also served as a force for increasing the political control from Spain[1]. Built as a group of building, in which the civil and religious center was the church, the missions constituted in the institution of strong relations among the friars and local people, certified also by the presence, around the church, of other spaces as the convento, rooms for the natives, shops, kitchens, schools etc. Several orders missionized the vast territory of Spanish America: initially the Spanish missions in the southwestern United States were stablished in California and Arizona by the Jesuits, while the Texas areas were under the control of Franciscans coming from Mexico and New Mexico. The presence of the Franciscan friars in Texas is strongly related to the single city of San Antonio, which characterized one of the most important advance points[2]. The city of San Antonio has five Franciscan missions, founded at the beginning of eighteenth century, the oldest of which is San Antonio de Valero[3], founded in 1718 by Father Antonio de San Buenaventura, while the entire California comprised 21 Franciscan missions, which constitute the Camino Real, among the peninsula of the Alta California.

After an initial period of ascent, in the mid-nineteenth century the missions experienced a phase of progressive abandonment, due to the secularization, involving the call of the friars to Rome, due to increasingly flawed relationships with the natives of the place, as well as to the advance of independent Mexico. All the Franciscan missions, after the secularization in 19th century, lived a phase of abandonment and decay which took almost a hundred years, at the end of which the romantic interest of the ruins, together with the local efforts to give back to original aspects - modified also by the destruction due to the natural phenomena, such as the earthquakes or floods – involved the first efforts of preservation. Especially, the Californian missions had been gravely interested by earthquakes, originated in the San Andrea's fault [4]; the climate also, with the proximity to the sea, usually favored hurricanes and floods which, together with the conditions of decay and abandonment, involved more damages. In some buildings, all these natural events defined the abandonment of the construction works and the repositioning of missions in safer areas [5]. Also Texas presented a comparable situation, with the damages due to the natural phenomena [6], entailing damages.

The restoration works performed by several figures and associations, as, for example, the HABS and the CCC - whose activity found in the Roosevelt's New Deal the starting point - had a large influence in this overview during especially the Thirty Years, with emblematic interventions due to the recovery and restoration necessities. After the first experimentations, among which the Alamo's restoration constituted one of the most interesting application of reinforced concrete elements, all the analyzed restorations of the research were performed in the Thirty years.

Structure of the Chapter

The chapter, as the previous about the Italian contexts, is divided in more sections: the first paragraph aims to describe the foundation, development and decay of the Franciscan missions in the United States, deepening also their architectures, with materials and form used in the constructions; the second part is related to the restoration applications and the development of the use of reinforced concrete during the interested periods of restoration, trying to understand, also in this case, the development of the applications and approaches to the historical heritage with the modern means; the last part of the chapter aims to describe some of the significant and emblematic restorations in the studied areas, as the missions of San Antonio de Valero and San José y San Miguel Aguayo, both in the city of San Antonio, Texas, and the mission of Santa Barbara in California. All the mentioned interventions represented particular approaches to the constructions, according to the different periods of realizations, and trying also to keep attentions on the designers of the works, which can be considered as precursor in the application of new construction systems on historical buildings.

notes

[1] Newcomb,1937.

[2] Fisher, 1997, 1998.

[3] Today is better known as the Alamo, the legendary fortress in which in 1836 Texan people were killed by the Mexican army after days of heroic defense.

[4] Tragically renown for the strong intensity earthquake from which have origins, which characterized the entire history of the territory (Toppozada et al., 2004).

[5] Usually during the constructions of the missions during the 19th century.

[6] Differently from California, in Texas only hurricanes and floods.

4_1

FRANCISCAN MISSIONS: INTRODUCTION

Beginning, development and architecture of the missions

Spanish Colonization

Spanish colonization of the Western Hemisphere began in the Antilles, along the Caribbean and the Gulf of Mexico. It took rot on the mainland in 1521 when Henando Cortés conquered Mexico City, the most important Native American urban center in the New World Starting in the following year, the conquerors rebuilt Mexico City as a Spanish municipality. From this beginning, the Spanish fanned out to North and South America, creating new cities and towns, most often on the sites of Indian population centers they had destroyed. Gridiron plans were imposed on former Indian settlements. By 1574, the Spanish had created newly 200 cities and towns with a total urban population ranging from 160 000 to 200 000. The Spanish divided the settled areas of the Western Hemisphere into colonial administrative unites headed by governors. The provincial governors referred all important matters to the viceroy in Mexico. During the colonial period, several orders missionized the vast territory of Spanish America; of these, the Franciscans and Jesuits were the dominant forces within the United States borders. The Jesuits occupied Lower California and Arizona until their expulsion in 1767, while the Franciscans established missions in the northern areas of Spanish America, such as Florida, New Mexico and Texas. After 1767, the Franciscans dominated the entire borderlands [7].

Franciscan Missions

Although their major objective was to spread Christianity among the natives, the missions also served as a force for spreading Spanish culture and political control. Essentially, they strove to change the nomadic Native America into a copy of an urbanized Spaniard. The mission tended to be located near concentrations of the Native American population[8]. Some were clustered in densely settled areas, some were transitory, while others served as permanent links in a long chain of missions. Much of the northern frontier of New Spain remained unchanged for two centuries after the conquest. The northern frontier offered a hostile environment and little in the way of precious metals. Rather than a continuous line denoting Spanish control, they established islands or enclaves of control separated from the principal settlement by deserts and hostile natives. According this reason, any of the early missions were defensive in character, with massive construction and black walls. Others had crenelated parapets reminiscent of military architecture.

Between 1769 and 1823, a total of four praesidios[9], twenty-one missions and three pueblos [10] were founded in the Alta California[11]. The missions were localized in the areas next to the existing villages populated by the natives, in a way to control them and be close to their sources, as water and arable terrains [12]. At each new establishment, the Franciscan friars were forcibly educated in the nuances of the local environment. The early missions of California were moved to new sites within their first few years, primarily away from floodplains; also, some of them were moved several times. Instead, the later founded missions, from the previous experience, were not moved[13]. Founded from the 1718, with the creation of San Antonio De Valero Missions, renowned today as the Alamo, the Franciscan missions in San Antonio increased radically in the following decades, with the creation of other four missions to the south of the city, forming the “Mission Road” of San Antonio.

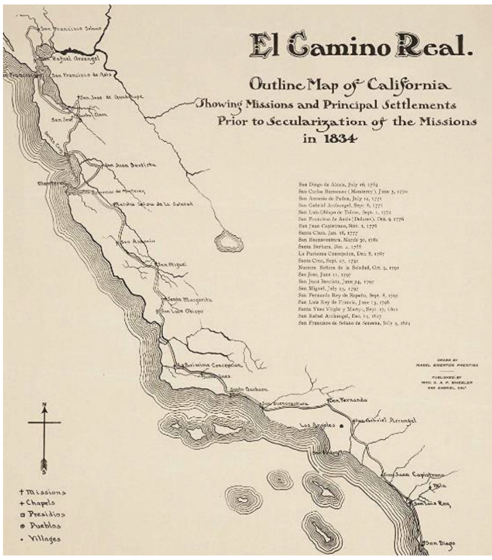


Fig. 4.1 - left
El Camino Real. Map of the 21 Franciscan Missions of California (1903).

Fig. 4.2 – right
The villa and presidio of San Antonio de Bexar: together with the Franciscan Missions (1939).

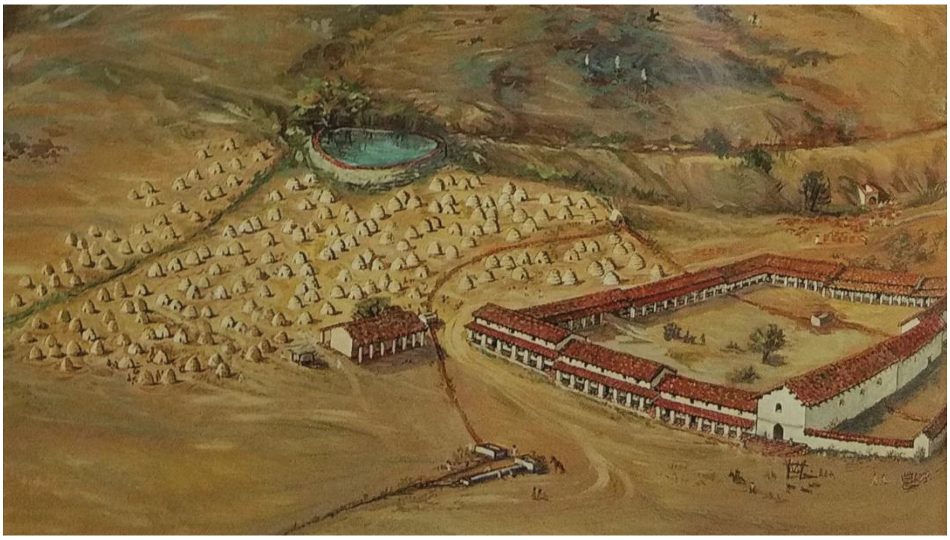


Fig. 4.3
Scheme of the Franciscan Missions, with the realization of the constructions next to the local villages (2009).

The aim of the friars consisted in the education of the local populations to the European society, with the management and the acknowledge relative to the arts, the practices and the realization of constructions. The main promoters of the first settlement in this area were the Spanish Franciscan friars Junipero Serra and Fermín Francisco de Lasuen, who, after their experience in Mexico, they came in the succession times and founded eighteen of the twenty-one missions of California. The missions constitute complex architectural groups of buildings: the center of the community, the Casco, typically included a closed quadrangle of four long adobe sides, one of which was the church, as spiritual and educational center; its towering façade dominated the plaza, where public ceremonies took place, residents socialized, and visitors arrived. The priests' residence building, the convento, typically flanked the church and provided the only public access to the closed quadrangle behind. Several conventos had two stories, and most boasted corredores, covered exterior walkways. The convento contained the *sala* – reception hall – an office with library, a kitchen a dining rooms for visitors, storerooms, and a private chapel. The other two sides of the mission quadrangle –

Fig. 4.4 a/b
The Franciscan Mission of Santa Barbara in California (NYPL). Postcards of the exterior and church interior.

those connecting the church and convento wings – contained workshops, storage areas[14]. The architecture of the missions is related also to the necessity of evangelize the local natives: reference and control center, the formal result must express also protection and prestige, and at the same time it must also leave a message of poverty, which is one of the bedrock of the Franciscan rule. The proposition of a language as the balance result of different cultures absorbs and uses the local experiences, giving back an original new identity, supported by an external world.

Architecture of the missions

Usually, the architects of the missions were the friars themselves[15] ; however, in some occasions, there were necessary other project and executive helps, obtained by the artisans enrolled in the Spanish armies or craftsmen sent specifically from the provinces, which remained for short periods. The architectural knowledge of the friars were limited; they took references from the architectures drawn in book they brought in the new continent or, also, they tried to reproduce the same place they remember from their last experiences[16]. In this way, the models and reproduced elements determined the figurative result of the missions, while the construction is more related with the context, through the use of local materials and workers. The churches were realized with different materials, due also to the period of foundation and the availability of specialized workers. The first settlement was realized in adobe brick, with base mud mortars, on stones foundations. Also, other churches were built in adobe and *ladrillo* – bricks in terracotta with water-isolating properties. Some of the most important missions, trying also to show their ambitious attempts, were realized in stones, which were cut and worked by specialized workers, specifically educated[17]. The natives, who usually lived in wood conical constructions, did not have the appropriate acknowledge about the use of other materials, letting the use of the local or close resources. The use of the stones, which occurred later and it was related to more qualified workers, had been limited to the biggest and most important buildings, morphologically and typologically more complex, with also strong relation to the style of the European baroque[18].

There is a strong relation among the workers and the local materials: the necessary time occurred for the construction of the religious buildings, variable from four to five years, the time for the works was also related with the manufacturing of the materials [19] and to the thickness of the bearing walls[20].

During times, these correlations of aspects returns an identitary reference, characteristic of the place, which is also balanced between the two different cultures. The references to the Spanish architecture are clear in the functional and structural aspects of the missions, as the lively decorations, able to stand out the towers, windows, openings, gates, facades, domes… on white walls, calling the Arabic influence in the Spanish architecture. The distinctive aspects can be also briefly reported to the presence of big and thick walls and buttresses, columns, continuous systems of arches, gables, bell towers[21], cantilevers. The cloisters in the conventos, which are typical to find in the missions, took the references from the

Spanish architectures, evident also in the use of square pillars without decorations[22]. The decorations represent also another meeting point among the cultures, inserting in the ornamental topics some forms taken by the nature, already used in the local representations: these choices represent also symbolically the confluence of the local language in a larger matrix, placed as the logical development.

The architecture of the Franciscan missions highlights a Spanish European matrix, also imported in the Mexican colonies, with references to the roman and renaissance architecture, to the Arabic influences in Spain, enriched with some local elements as the *espadanas*[23] and the structures of the *campanarios*. Also the local Mexican architecture is important in the missions' architectural definition, with some common elements as the domes[24]. Differently from the roman and renaissance domes, these are domes with only one cap[25], with a section of lowered round arches, usually covered with glass colored tiles, with an upper lantern. The colored decorations - which today are no more visible due to decay phenomena – appear diffused in the monumental Franciscan architectures of the central America[26].

notes

[7] Lee, 1990.

[8] Lee, 1990.

[9] Military settlements.

[10] Small local settlements.

[11] The Alta (upper) California is the upper part of the Californian peninsula; differently from the Baja (lower) California, which is Mexican territory, the Alta California is located in the United States' territories.

[12] Kimbro et al., 2009.

[13] Ibidem.

[14] Ibidem.

[15] Lot of times the friars-architects were renown.

[16] As from Mexico, in case of the friars came from the other Spanish provinces in America, or from Europe (Spain, Italy) in which they studied and had their education.

[17] The construction of the earliest mission buildings was of wooden posts of pine or cypress set close together and plastered inside and out with clay. This mode of constructions was employed until 1780, except of course where wood was scarce, at which place adobe or sundried brick were used. In 1780, the adobe brick, a material widely accessible and entirely not combustible, came into general use. The materials used in the construction of the mission buildings were adobe, boulders, sand-stone, lime-stone, woods of various kinds, burned tiles and bricks, mortar. The boulders were, where used, generally employed as foundations for the adobe walls. The adobe bricks and blocks were used in various ways. Sometimes, different materials were combined in interesting solutions (Newcomb, 1914).

[18] Sewall, 2013.

[19] In particular, also the time of drying of adobe brick.

[20] Specifically, in Texas the most used materials were adobe (sun-dried), burned bricks, and stone, laid in lime and sand mortar, while in California, beyond the previous materials, also the burned bricks were used (Newcomb, 1937).

[21] Sometimes also with the upper lantern.

[22] Related also to the difficulty of stone work, due to its faint gable and the lack of qualified workers.

[23] Rib bell tower.

[24] An identifying and important element of the territory, testifying also the handed down message according which "each village has a dome" (Kimbro et al., 2009).

[25] differently to the Italian caps of the intrados and extrados.

[26] Newcomb identified the elements which characterized the architecture of the missions in the different contexts. Firstly, in Texas, he underlined the plan form of the buildings, basilica or cruciform, with double towers at the facade of a pierced belfry crowning the facade; the roofs were formed of low masonry domes or tunnel vaults, while the walls were of heavy masonry, bare and unadorned except upon facades or around openings; also, the church presented lot of fine decorations, presented also in the interior elements of the churches. In the California analysis, he notated the arcaded spaces of the cloisters, as corridors surrounding the internal patios of the missions; the solid and massive walls, piers and buttresses were characteristic of the structures, with the purpose to resist the lateral thrusts of arches or vaults; the terraced bell towers with dome and lantern were used on the more important churches, while there were no decorations as the ones found in Texas' missions. (Newcomb, 1937).

4_2

ANALYSIS OF THE INTERVENTIONS

Restoration in the first half of the twentieth century

First efforts of preservation in United States

The restorations pursued in the twentieth century in the American context followed the development of the restoration theory, showing also the new necessities and needs which started and involved the use of modern technologies in the restoration applications. In particular, both California and Texas, with the decay of their monumental buildings and the improvement of the first preservation authorities[27], started the restoration campaigns which, after the first experimentations in the Twenty years, during the Thirties interested large part of the historic buildings.

The first debates about the preservation of the missions had been already started at the end of the previous century, with the attentions to the historic heritage caused of the interest of the romantic painters, photographers and also novelists, as Henry Chapman Ford, Carleton Watkins, Helen Hunt Jackson, which determined the interest for the architectures by the local population[28]. The social awareness about the necessity of interventions was spread also among common people: also, newspaper articles underlined these necessities.

> *"The twenty-one missions, now decaying and in ruins, which lie along the highway from San Diego to Sonoma we've brought back to life through the activities of the California Mission Restoration Association, which is now instituting a movement to culminate only when the last mission has been restored in its ancient picturesque splendor. […] The work of re-establishing these missions is now under way. From the archives of Madrid and from the Church records left by Father Junipero Serra the data has been secured by Father Mestres. All of his*

knowledge as mission historian, archaeologist and builder is to go into the completion of the feat task before him, a task which, when completed, will find the landmarks of California the same as they were first built along El Camino Real." [29]

CCC, HABS and Index

Since the thirty years, the work by the architect Philip T. Primm[30], who was regional inspector of the Civilian Conservation Corps (CCC)[31] increased the people interested about the recovery of the decaying architectures, starting the first collaboration with the private associations and the local authorities since the 1934. The following year, with Roosevelt's New Deal it had been promulgated a federal program for the identification, cataloguing and collection of data about the historic heritage, thanks also to the economical availability from the foundations, as the CCC, the Historic American Building Survey (HABS)[32] and the Index of American Design (Index)[33]. The documentations represented the result of deepened analysis and survey conducted in the selected areas: a digital heritage of drawings, photographs, relations which describe the state of art of large part of the historic architectures before the intervention, and also the approaches and the principles at the base of the next realized interventions of restoration, preservation and recovery. During these years, some churches, even if the missions were secularized, continued to conduct their function being service of the local population, and so becoming places for the social and cultural preservations.

In California, the beginning of the 20th century is characterized by the happening of two violent earthquakes, with several damages to the entire built heritage, interesting in particular the Franciscan missions. At the beginning of the century, the entire area had been interested by the strong earthquake of San Francisco in April 18th 1906, which caused more than 3000 victims and several damages and collapses in large part of the territory; in this case, lot of historic buildings, in particular some of the Franciscan missions had serious damages and collapses.

Few years later, the event of Santa Barbara, which occurred in June 29th 1925, caused damages to the local territory, with collapses of buildings and damages to the missions [34]. The Santa Barbara earthquake of 1925 [35] pointed out one of the problems of the rapid growth of communities in California - sub-standard construction, often encouraged by the amicable climate, leads to structures which give way all too easily in the shaking of an earthquake. Such was the

Fig. 4.5
The cover page of the novel "Ramona", the flier for the enrollment in the CCC, the spot of a lemonade with the mission of San Fernando in the back (Kimbro, 2009)

problem in the Santa Barbara area when the quake of June 29, 1925 struck [36]. In the business district of Santa Barbara, an area of about 36 blocks, only a few structures were not substantially damaged, and many had to be completely demolished and rebuilt [37].

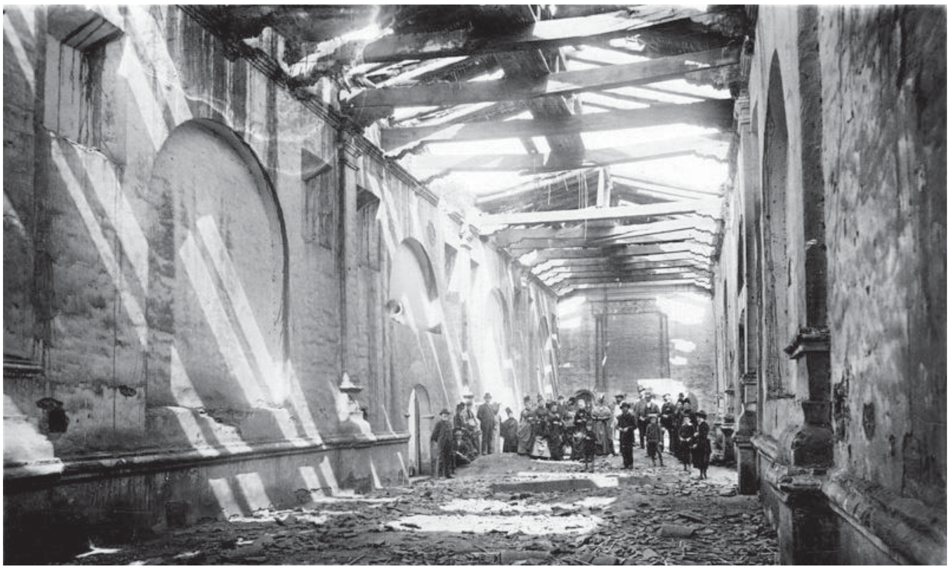


Fig. 4.6
Interior of Mission San Fernando in ca. 1812 (1900)

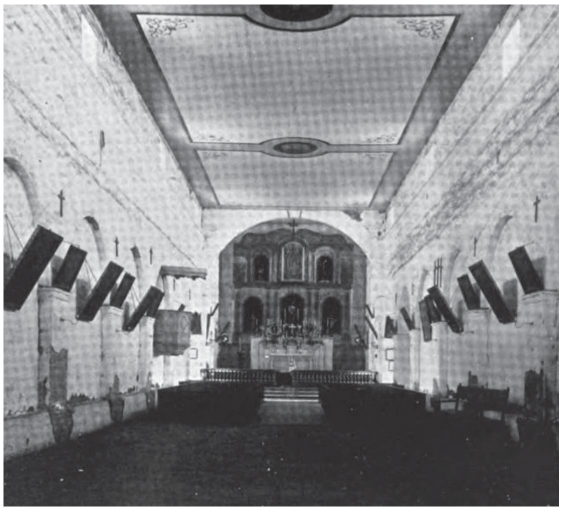


Fig. 4.7 (left).
The San Juan mission after the earthquake of 1906 With the collapse of the convento's walls (SJHS).

Fig. 4.8 (right)
The interior of the church from a picture of 1900.

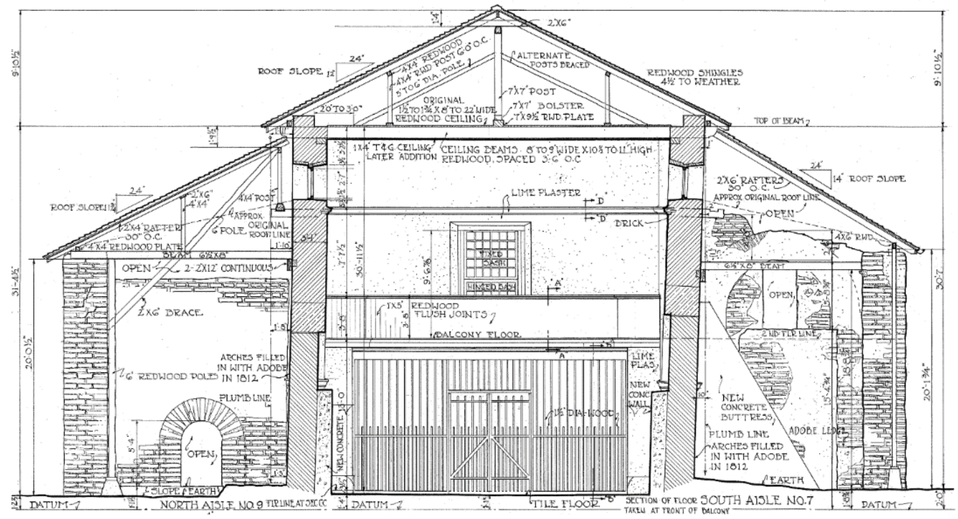


Fig. 4.9
Section drawing of the church of San Juan in 1934 (HABS). It is possible to individuate the additions in reinforced concrete, as the buttresses and the base thickening of the walls.

Restoration works in California

After the 1925 earthquake, restoration works began with funding by the State of California. The project consisted in the insertion of reinforced concrete structures inside the existing masonry, with top beam systems and reinforced concrete buttresses. The main façade was excluded from this phase of work and was only restored in the collapsed parts via cement injections [38] (B_2|2).

The other areas interested by the two destroying events started to be recovered in the same years of Santa Barbara's recoveries. In particular, the San Juan area, whose mission suffered lot of damages with the first event, had been recovered only from 1926. San Juan mission [39], suffered lot of damages with the event of 1906, with lot of collapses in the areas of convento and the lateral sides of the church, leaving the central nave with lots of overturning behavior, going to collapse. The diffused out of lead situation of the main walls did not involve shared solution for the restoration, to the point that the first decision after the damages had taken only in 1926, seventeen years after the earthquake. In the first restoration project, the collapsed parts, as also the *espadana* and the bell tower, were rebuilt, while the main walls of the nave were left in their oblique position, with the insertion of external buttresses in reinforced concrete and small thickening – always in reinforced concrete - at the bases of the walls[40] (B_2|1).

Other interventions in California presented the use of reinforced concrete as static problem solver, trying to recover the damaged and decaying architectures. Lot of the interested missions had been interested by the application of the material in the roof support elements. In mission of San Miguel Archangel, whose restoration had been realized in 1934, directed by Jess Crettol[41], there were inserted tie and bond beam in reinforced concrete, while the roof had been made by steel structure, supported by concrete beams[42]. Reinforced concrete had been used also in the lintels above windows and doors, and in the tie beams along the perimeter of the room between the church and the monastery (B_2|4). Mission San Fernando Rey, instead, had restored with the insertion of top beams and columns in reinforced concrete in the brick walls[43]; also in this restoration, reinforced concrete is used also in the lintels of the openings of windows and doors (B_2|5).

As also in other American missions, sometimes the use of reinforced concrete, instead of the structural recovery after quake events, interested the creation of lost elements, such as domes, arches, buttresses. San Luis Obispo[44] represented an interesting case in which the modern material had been used for the recreation of the lost narthex, in front of the façade [45]. Realized in 1933, after the release of the Athens' Charter, the new portico had been completely realized in reinforced concrete, independent from the existing building; also the linking beams with the façade had been built in reinforced concrete[46] (B_2|3).

Fig. 4.10
Section detail drawing of the church of San Miguel Archangel (HABS). The top beam in reinforced concrete had been inserted supporting the system of the roof.

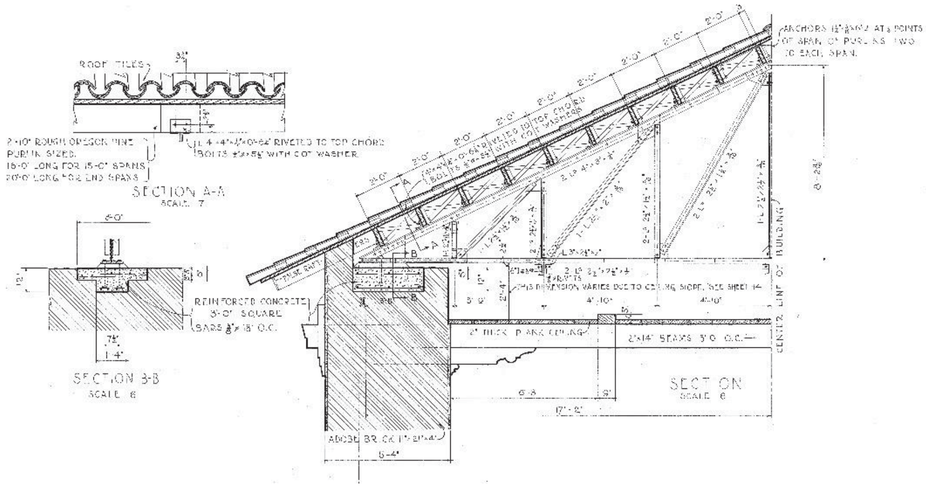


Fig. 4.11
Section detail drawing of the church of San Miguel Archangel (HABS). The top beam in reinforced concrete had been inserted supporting the system of the roof also of the convento.

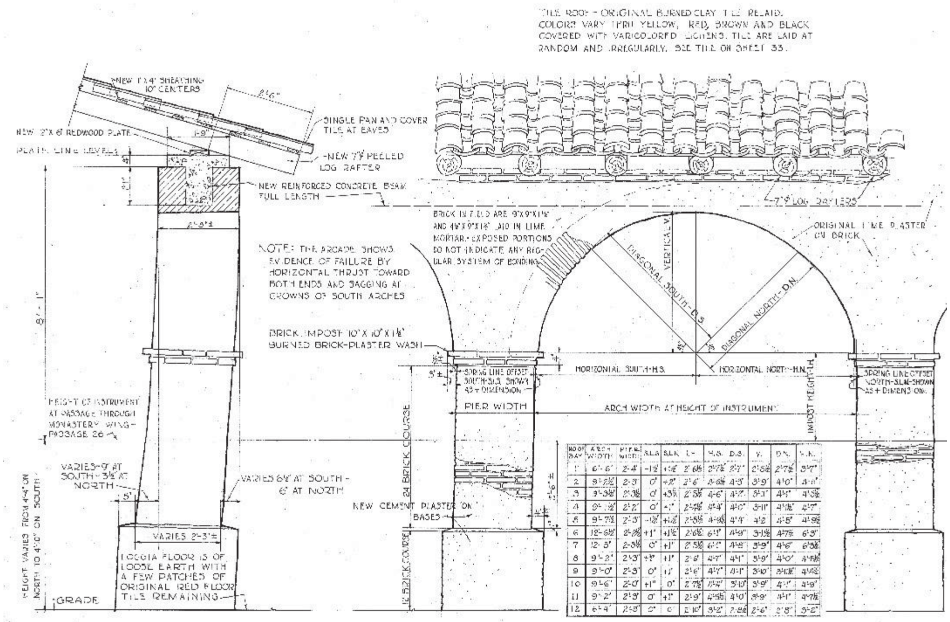
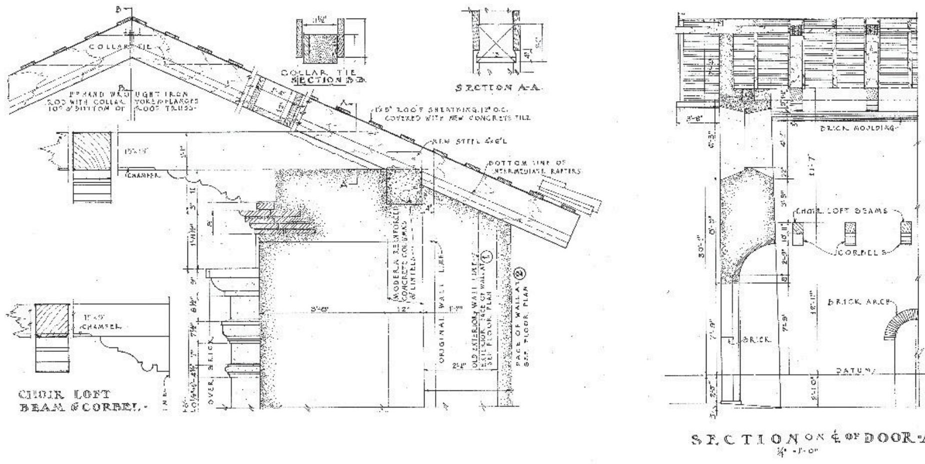


Fig. 4.12
Section Detail Drawing of the Mission of San Fernando (HABS). It is possible to see the reinforced concrete top beam and the indication of the column.



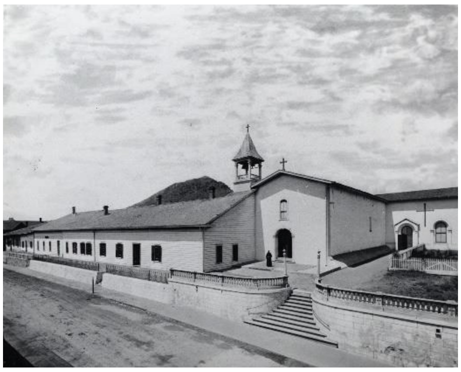


Fig. 4.13 - left
Painting depicting the grounds of the Mission San Luis Obispo, c.a.1865 (USC)

Fig. 4.14 – right
The refurbished mission in 1905, with its adobe walls covered in wooden siding and the façade without the narthex (Kimbro, 2009)

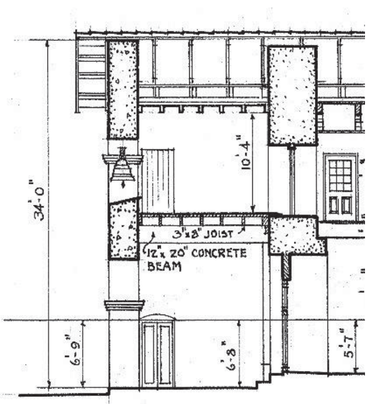


Fig. 4.7 - left
Front elevation of the mission San Luis Obispo, with the narthex (HABS).

Fig. 4.8 - right
Section drawing of the mission of San Luis Obispo (HABS). The narthex and the linking elements had been realized with elements in reinforced concrete.

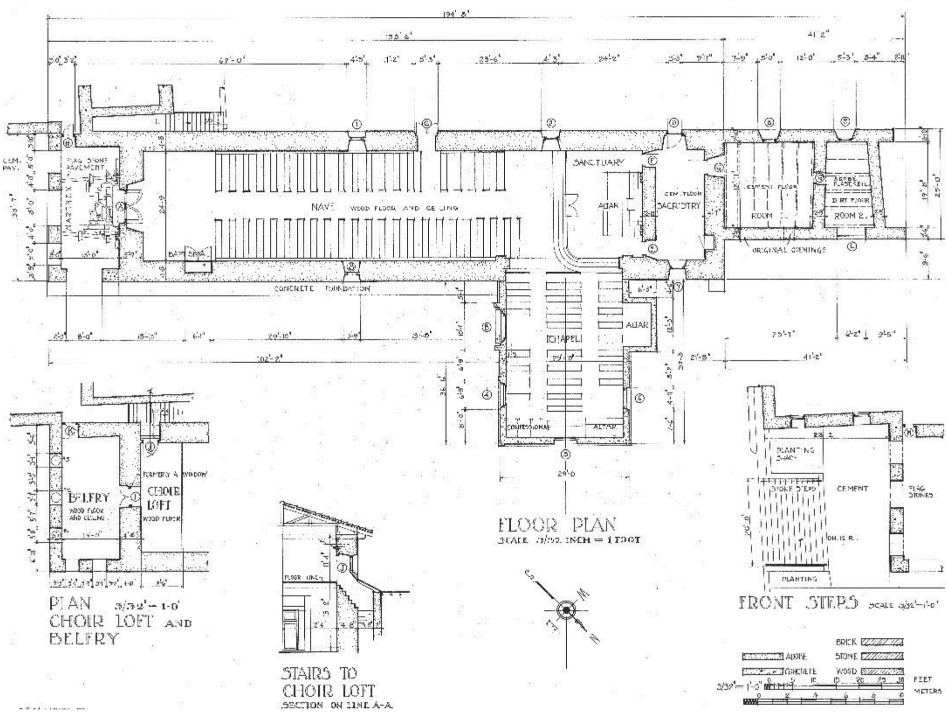


Fig. 4.9
Plan of the mission San Luis Obispo with plan details of the narthex (HABS).

Restoration works in Texas

In Texas, even if the area is not interested by the seismic risk, the Franciscan missions were in the state of decay since the end of the eighteenth century, in some cases also with collapses. The city of San Antonio, as the other parts of Texas, suffered the climate of the area, with hurricanes and flooding which caused the collapses of roof and the deterioration of the structural elements. With all these forewords, it is easy to understand why also in Texas there were necessary restoration interventions, which were pursued since the Twenty years, as the Californian area: as the other context, also in this case the necessity of structural reinforcement involved the use of modern materials, such as the reinforced concrete, which, few years before the release of international documents, represented precursor approaches to the historic preservation.

In this case it could be an emblematic example the restoration of the Alamo, which is the old mission of San Antonio de Valero, the first settled Franciscan mission in the city, which in 1921 had been interested by the reconstruction of the roof with the insertion of elements in reinforced concrete[47]. The architect of the project, Alfred Giles[48], asserted his positive position about the application of reinforced concrete elements, instead of others, cause of the high level of performance of the modern technology, and the ease and velocity of works[49] (B_1|1).

The other restoration works pursued in San Antonio found in Harvey Smith the most important precursor and designer. In particular, lot of works presented the insertion of the modern material, put in the buildings as the only possible solution to the problem of reintegration[50]. By 1928, Harvey P. Smith[51], one of the finest architects in San Antonio, had been commissioned to direct his first major architectural restoration project - the Spanish Governors' Palace[52]. Site excavation began in 1929, and by 1931 the Spanish Governors' Palace was open to the public. The practical knowledge gained from this project enhanced Harvey Smith's expertise as well as his reputation. He also established several criteria that guided his preservation and restoration work:

> *"To preserve or restore? This ubiquitous question must be settled at an early point in the project. Each situation must be studied and evaluated on the basis of existing conditions.*
>
> *Research before excavation must be thorough and accurate to minimize disturbance of original, existing construction.*
>
> *All architectural remains must be accurately recorded.*
>
> *Authenticity must be carefully established as the work and research proceed.*

A progression of architectural drawings including field drawings, measured drawings and restoration drawings are essential." [53]

According these points, it is clear that Smith was conscious about the development of the restoration theories, which would be declared in the following Athens' Charter.

Furthermore, he drew the specifications and supervised the difficult restoration[54] of the dome and nave of the Mission San José in 1937[55] (B_1|3). Through the years he has carried on extensive research not only a Mission San Jose but at all the old Spanish Missions in and around San Antonio. In an earlier memo the Archbishop referred to Mr. Smith as "the outstanding Mission architect of Texas" [56].

Since this moment, large part of the recovery actions was pursued with the use of reinforced concrete, which, after the release of the Athens' charter and the other international documents, started to be commonly used as the only solution in restoration designs.

The common base of the interventions is represented by the consciousness of the vulnerability of some construction typologies: it is certified with masonry buildings present weak point according to their nature and in structural elements such as arches, vaults and domes; the main target had been constituted by the aim of improve the structural resistance of the buildings without modify the form. In this way, reinforced concrete started to be used, sometimes with only few additions, in other cases with the insertion in all the building parts.

notes

[27] Cf. chapter 1, with the description and the development of the restoration associations and theories in US.

[28] Kimbro et al., 2009

[29] In *Spanish Missions to be Restored* (1921).

[30] Phillip Primm, an Illinois native, studied architecture and landscape gardening at the university of Illinois in Urbana, then practiced landscape architecture in Cleveland before moving to California, where he eventually was hired by the federal government. (Brown 2018).

[31] Wayde Brown described the role of the establishment and the targets of the Civilian Conservation Corps: *"The CCC was a major component of President Roosevelts offence on the economic crisis of the 1930s. With a military-like administrative structure, the program took unemployed males, age seventeen to twenty-eight, often from urban areas, and placed them on work projects for a period of six to twenty-four months. The men received: clothing, accommodation, and a monthly stipend; development of literacy and other basic skills was sometimes incorporated into the work program. During the program's existence, three million young men worked on CCC projects, chiefly in the areas of reforestation, soil conservation, and national and state parks."* (Brown, 2018) (Cf. also Chapter 1, note no. 29).

[32] The Historic American Buildings Survey (HABS) is the nation's first federal preservation program, begun in 1933 to document America's architectural heritage. Creation of the program was motivated primarily by the perceived need to mitigate the negative effects upon history and culture of rapidly vanishing architectural resources (Cf. also Chapter 1, note no. 31).

[33] The Index was a campaign to document the rise and development of American design in order to define the nation's cultural and aesthetic identity, thereby countering some contemporary perceptions that, compared to European nations, America lacked a rich historical artistic tradition. The purpose of the Index was not merely to create an antiquarian catalog but to provide inspiration for a new modern art that, rather than imitating European styles, would be truly American. For California, the missions provided the richest heritage and the Index teams documented items of wood, copper, architectural elements, and religious items associated with both the Spanish and Mexican periods. In the years following WWII, the United States became more open to influences from the rest of the world: the Index's work resulted in the most comprehensive pictorial survey ever produced of American society and art.

[34] On the afternoon of August 13th 1978, the Santa Barbara area was shake by a magnitude 5.1 M earthquake which caused moderate damages. The epicenter was located just offshore, 3 km southeast of Santa Barbara, with a hypocentral depth of nearly 13 km.

[35] Corbett et al., 1982.

[36] Unlike the great San Francisco earthquake of 1906, which was accompanied by a fire that led many to confused conclusions about what caused most of the destruction of buildings, the Santa Barbara earthquake produced no fire, and demonstrated clearly the destructive capability of the earthquake alone.

[37] In all, about $8 million of damage occurred, and 13 deaths were reported in connection with the earthquake. Had the quake occurred when the business district was crowded with merchants and customers, the death toll would likely have been greater.

[38] The restoration work of mission Santa Barbara will be analyzed in the last paragraph of the chapter.

[39] The mission had been founded in 1794, and whose system with a single nave had been modified from 1808 to 1814 after a series of quake events, presents a size three time bigger than the original, with the walls' height of 12m, the highest never realized; there are also a narthex in the front façade, positioned continually with the lateral convento.

[40] Today it is not possible to see these buttresses, because of they had been removed with a restoration occurred between 1975 and 1978, financed by the Monterey diocese; the works, aiming to remove the "modern" additions and give back the original aspect of the church, opened the main nave, creating other two lateral naves – which probably the church never had – according the suggestion of Harry Downie (from Sanchez G., 1989).

[41] In 1934, Father Wand, pastor at Mission San Miguel, invited Jess Crettol and his family to come to San Miguel to help restore the mission. They originally planned to do only a partial restoration and later decided to do a complete job on the foundations of the old quadrangle. When they started the job, the mission had almost been reduced to rubble, they made adobe bricks and restored the quadrangle first. Jesse then built the bell tower at the south end of the mission property while his father built the one adjacent to the mission cemetery.

[42] There are sections that explain the anchorage of the steel truss to the concrete beam thanks to bolting systems.

[43] To which the rafters of the roof are linked by steel plates.

[44] The mission had been founded in 1772 and modified its aspect during times.

[45] Probably the narthex was an addition to the original system, and had been removed after some quake events occurred in the 19th century.

[46] But only at the first level, the beams of the second level are in timber.

[47] The restoration works of the Alamo will be analyzed in the following paragraph, with the specific description.

[48] Cf. note 65.

[49] Ciranna, Felli, Lombardi, 2019.

[50] In particular, this aspect is evident in the restoration of Mission San José.

[51] Harvey Smith and his brother left their home in Minneapolis, Minnesota and, directed by the map, headed for San Antonio. Their first days were spent seeing the city. After some time, Smith grew to truly admire the city and its multi-cultural atmosphere. He decided then to make it his home, to begin his practice of architecture here, and to continue to study the five old stone ruins (from Smith JR, proceedings 80s).

[52] Smith spent over a year researching this project, and even visited Mexico City, Queretaro and Austin, to find necessary information (Ibidem).

[53] Ibidem.

[54] During the 1920's Smith had designed and built an extensive number of hotels, banks, office buildings and schools, but his interest was in historical preservation and restoration. He had made many a public speech on this topic to local groups, and as early as 1918 his articles had appeared in newspapers and magazines. (ibidem)

[55] Habig, 1968 b.

[56] Jennings, P. C., Housner, G. W., 1973.

4_3

SIGNIFICANT EXAMPLES IN TEXAS AND CALIFORNIA

From the Alamo to the "Queens of Missions"

This section of the chaper aims to analyze some of the most interesting intervention realized in the interest areas. In particular, they have been analyzed three different restoration interventions, pursued between the Twenty and the Thirty years, aiming to recover and restore three different missions, which, due to different reasons, needed to be recovered. While two examples regarding the city of San Antonio, which are the Alamo and the Mission of San José, the last case study regards the mission of Santa Barbara, in California's area.

The Alamo (Mission San Antonio de Valero)

One of the most important and first interventions, according to the importance of the building, the period of the restoration and also for the effect in the national context could be the works which interested the Alamo[57] (B_1|1). Built as the Franciscan mission of San Antonio de Valero, it was initially a place with services for the natives, as schools, shops, residential headquarters. The church[58] was designed according to the rule of Spanish architecture[59]. With the secularization of the missions, also San Antonio de Valero had been abandoned by the friars in 1793: the property outside the walls was divided among the mission Indians and a group of refugees from the Presidio Los Adaes, a military settlement close to the city. In 1802, While the property continued to belong to the Catholic church, the Spanish soldiers started to use the building as a fort, demolishing the arches with the ribs, and also the vault, for creating an inclined plan to carry the cannons to the top trench[60]. With the occupancy of Texan soldiers, the building maintained for other two years its defensive purpose, but becoming the Texan fort; it was the beginning of the battle[61] of the Alamo[62].

The church, since the first years after the construction, had been interested by different intervention regarding its roof system, which had been modified several times, due to the different purpose of the building[63]. Adina De Zavala, with the Daughters of Republic of Texas (DRT)[64] resumed the restoration and retained the custodian of the building[65]. They called for the project the architect Alfred Giles[66]. The proceedings of the annual meeting of DRT in 1920 reported the exposition of Alfred Giles about the restoration project, thanks to which it is possible to evaluate the approach to the building in the restoration intervention[67].

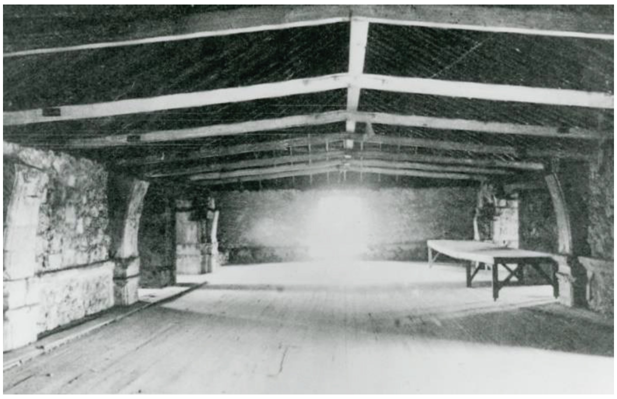
> *"It gives me pleasure to appear in co-operation with this patriotic organization and be of assistance in so great a work as re-roofing the Alamo. These drawings have been made up to make a permanent and satisfactory roof on the Alamo. In order to preserve and keep the Alamo Chapel from slow decay and ruin, the Daughters of the Republic of Texas proposed to construct the roof as near as possible to the original shape. The present tin roof erected some years ago after the ruin of the original stone roof is now entirely inadequate and leaks in many places. The new roof will be of concrete arches tinted so as to match the weathered stone of the old structure. […] Local scientific societies will be encouraged to keep their specimens and exhibits in the Alamo for the convenience of visitors".*

The architect also emphasized the fact that the roof would be constructed solely for the purpose of preserving the building just as it stands. Also, he explained that no outside buttresses would be built to support the roof but that it would be vaulted, reinforced with concrete, stained to represent old stone, and would be built to support its weight without any strain on the old walls.

The main purpose of Alfred Giles, who was conscious about the import ant role of the building in San Antonio's history, was focus on giving back the original aspect of the building. The structure of the vault, according also Giles himself, was conforming the original: the system of the vaults was different from the original, maybe cause the lack of enough documents and historical information about it; also, the research works and discoveries of Ivey are recent. The proposed system was based with a continuous barrel vault, supported by the walls, in the nave and also in the transept. Cause the different sizes of the radius, in their crossing, it was designed an irregular cross vault.

The restoration works, according also to the newspaper of the period, took a restricted time, the period from April to the end of September 1920, and started after the visit of vice-president Marshall, who wanted to see the Alamo finished until his return in San Antonio. Alfred Giles didn't' finish the works: he died in August 14th of the same year. His son, E. Palmer Giles[68], finished to direct the works and he was present at the reopening ceremony of October 9th.

Fig. 4.17
The Alamo after the battle of 1836 in a drawing from the war report by Capt. George Hughes (TSA)



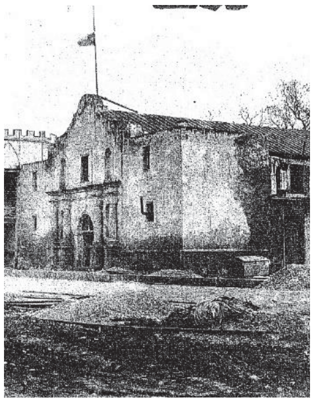


Fig. 4.18 - left
The second floor of the Alamo church, with the new roof in timber due the works of 1851(GLO)

Fig. 4.19 - right
Photograph of Alamo Plaza in 1880s. (Photograph of DRT, from Meissner)

Fig. 4.20
The Alamo works of 1920 with the scaffoldings on the facade (photo from DRT)

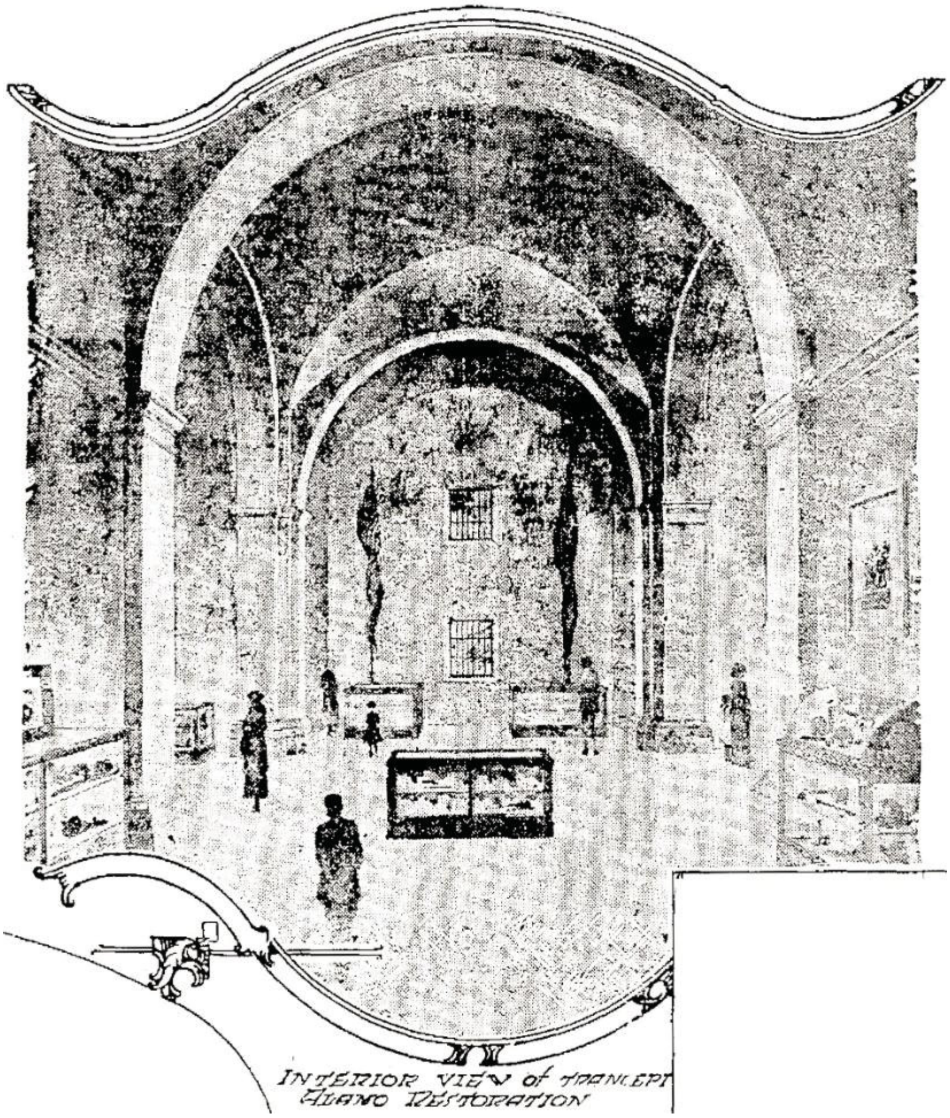


Fig. 4.21
Interior of the Alamo in a sketch by Alfred Giles Studio (1920)

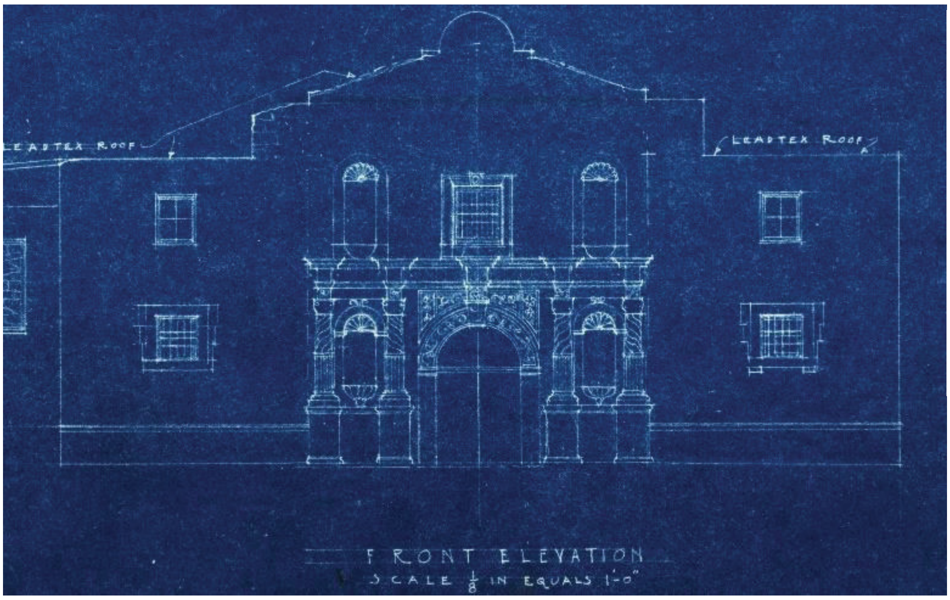


Fig. 4.22
The Alamo façade in the reconstruction drawing by Henry T. Phelps (1936).

Fig. 4.23
The mission of Santa Barbara in 1876 (MMA).

Fig. 4.24
The mission of Santa Barbara after the earthquake of 1925 (UCLA).

Mission Santa Barbara

The efforts of preservation of that period found in the intervention of the Franciscan mission of Santa Barbara in California (B_2|2) another interesting case studies, with the global approach to the structural improvement of the building with the use of the modern materials. Mission Santa Barbara, the tenth Franciscan mission founded in Alta California and called the Queen of the Missions[69], suffered different seismic events[70]. It was gravely damaged by the earthquake of June 29th, 1925, with visible damage to the whole architectural complex, including the church and convento. This was due to the collapse of several parts and the activation of local overturning behaviors of the façade.

> *"The towers to a great extent have already fallen, and what still remains is in such badly cracked conditions as to constitute a continual menace to passersby. Work will begin here as soon as permits are received to start on the restoration. Several of the tremendous buttresses have been cracked, and dislocated and they, no doubt, will receive next attention. […] Thousands of tons of adobe and broken masonry must be removed before the rebuilding gets under way. The outer wall of the mission with the original archways, so distinctive a feature of all the missions, will so be propped by heavy timbers […] If you wish to help restore our beloved mission please send donations made out the Old Mission Restoration Fund."*[71]

The restoration works, designed by the architect Ross Montgomery[72] started in 1925 with the aim of the reproduction of the church's state before the earthquake and finished in 1927.

> *"Before proceeding with the actual reconstruction drawings and the preparation of specifications for the restoration of the monastery and church comprising the Mission of Santa Barbara, it was necessary to take complete measurements of the structures as they exist in their ruined condition"* [73]

This first phase of acknowledge took one month; the architect, with the collaboration of several assistants, surveyed the entire building, with measurements, holes through walls for obtaining the correct dimensions and also some diggings for studying the foundation system. With the first analysis, the architect obtained accurate and complete plans of the old mission "as it existed before the earthquake". The architect, in the relation, individuated the target to be reach in the project, explaining also the reasons of the insertion of new materials, such as the reinforced concrete. Firstly, the project interested the convento, which had been serious damaged by the quake.

Fig. 4.25
Picture of Mission Santa Barbara after the earthquake of 1925 (USCS).

Fig. 4.26 – Fig. 4.27
left and right
Picture of Mission Santa Barbara after the earthquake of 1925. Detail of the bell tower (USCS).

Fig. 4.28 – 4.29
Pictures of Mission Santa Barbara after the earthquake of 1925 (Graffly, 2010).

"Levels and transits ere unknown in the building of the Mission originally, and the floors and wall through in no case conform to either perpendicular or horizontal planes. It will therefore be found necessary to plan the new work in such a manner as to conform to eccentric lines of the parts to be retained. It is the intention of the architect to conform exactly to the outlines of walls, floors, and roof that must be replaced with new material, so that when the work is completed, to all appearance it will be an exact replica of the original portions. [...]

No materials will be removed from the Mission, except parts that the earthquake has made dangerous, or that would be subject to speedy decomposition. Practically all the first story walls, floors and ceilings in the monastery portion can be kept intact."[74]

While the first level did not present so much damages to the structures, in a way to preserve them in the intervention, the upper level suffered the earthquakes, involving in a "complete ruin"; in this way, the only achievable way to the structural improvement is the reinforced concrete.

"It is found expedient to plan a reinforced concrete floor slab over the existing ceilings of the first floor. This slab will be supported on columns and girders f the same material. The column will be recessed into the old first floor walls and carried to the required foundation depths below grade.

The concrete work referred to will carry stone, adobe, and concrete walls forming the new second story of the monastery portion. All of these walls when plastered will create an appearance identical with the old. [...]" [75]

The works interested also the church, which had been severely shaken, in particular in the front facade and towers, going to collapse. Also, the covering system had been interested by the reinforcement with perimetral top beams in reinforced concrete.

"The towers must be removed to be point where the stone walls are found undamaged, and rebuilt using the original stones to a great extent, and binding them together with reinforced concrete ties. [...]

In both the monastery and church many large fissures have to be filled in with concrete or cement and the walls in which these fissures occur will have to be brought back into alignment with bolts and anchors. Even so it appears that it would be unwise to treat the mas bearing walls and better to carry the roof load on a frame of steel or reinforced concrete embedded in them.

Many of the old tile and stone floors throughout are in such a damaged state that they will likewise have to be reconditioned. The church roof in part and the monastery roof complete will have to be rebuilt and the remaining portions of the church roof reconditioned." [76]

Even if the relation of the project had been reported previous the intervention, in the specific after the first phase of the intervention, the works followed accurately all the reported recommendations. The upper part of the facade, even if it presented fissures and cracks, was not interested by the application of frames or ties in reinforced concrete, but it had been reinforced with only cement injections. After the appearance of cracks, caused by chemical reactions among the Tricalcium Aluminates inside the cement and Sulfates inside the original lime, which product is the Ettringite, bigger than the original particles, in 1950 the façade was restored again, inserting in this case a reinforced concrete beam.

Fig. 4.30
General plan of the mission of Santa Barbara (HABS).

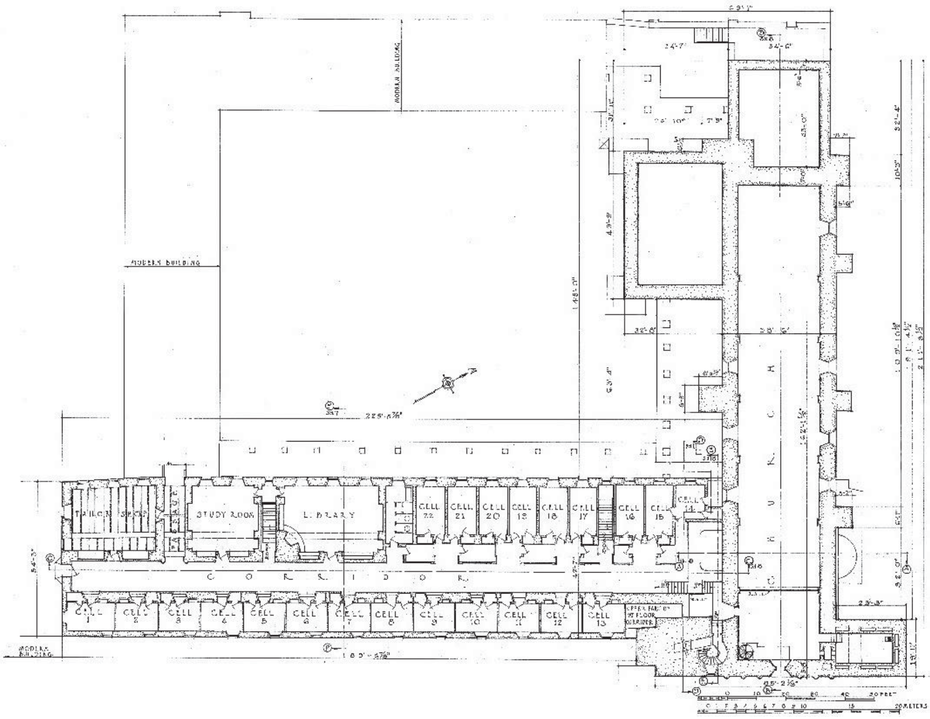


Fig. 4.31
Picture of Mission Santa Barbara during the restoration works, during the assembly the scaffolding in 1926 (UCLA).

Fig. 4.32
Picture of Mission Santa Barbara during the restoration works, with the scaffolding in 1926 (UCLA).

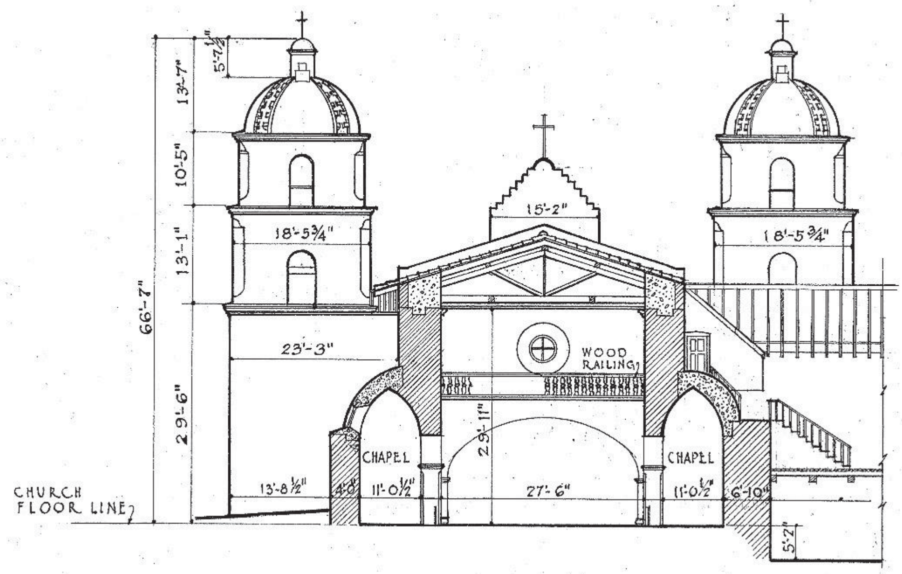


Fig. 4.33
Section drawing of mission Santa Barbara (HABS). From the drawing, there are identified the top beams and the buttress in reinforced concrete.

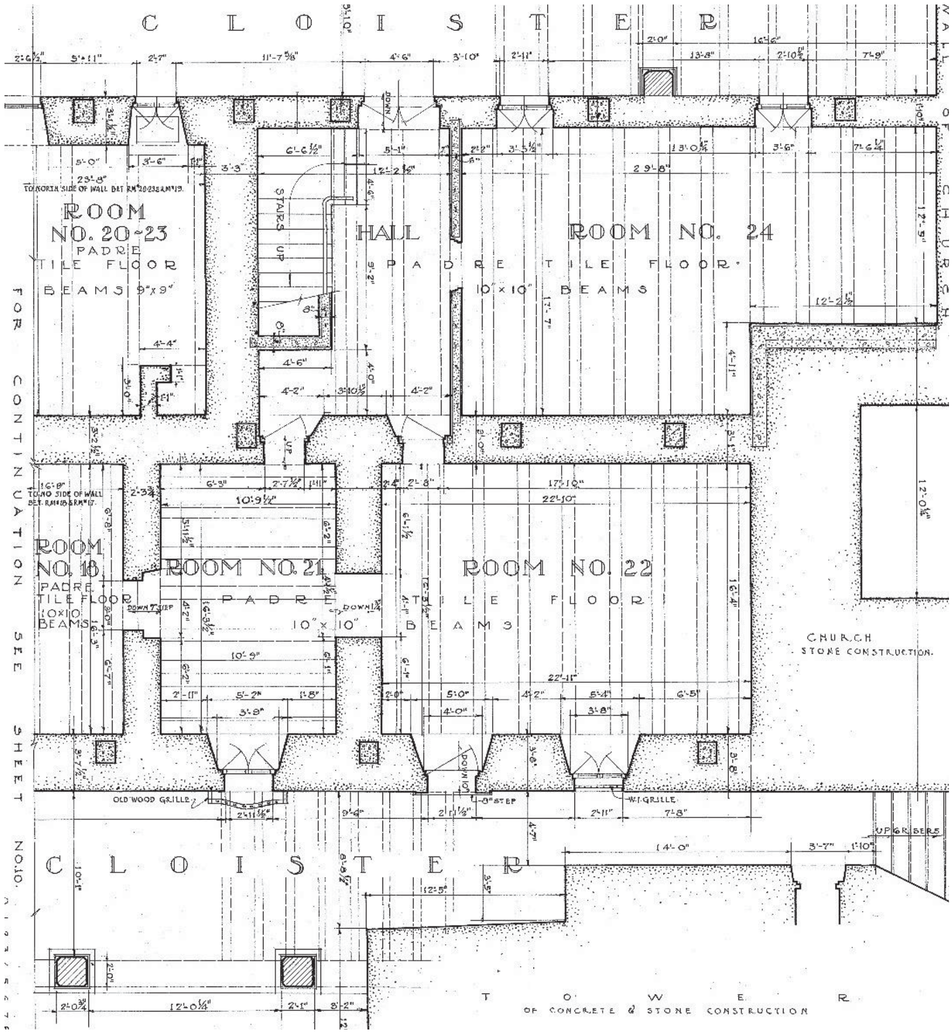


Fig. 4.34
Detail plan of the convento's spaces (HABS). The reinforced concrete columns had been inserted in the existing masonry.

Mission San José

Another intervention, with the insertion of reinforced concrete elements, had been pursued in the other mission of San Antonio, which is the mission of San José y San Miguel Aguayo[77], whose restoration works had been directed by the architect Harvey Smith (B_1|3). The church, after the collapse of the northern wall, the dome and also the bell tower occurred in the period between 1868 and 1928[78]. The restoration and recovery works started in 1933 and took four years[79].

Harvey Smith found a church without roof and with several damages to the main structural walls. His project aimed to redefine the collapsed parts and reconstruct the lost elements; in this way, he followed two different approaches to the building. First of all, the reconstruction of the tower provided, as also the other exposed case, the removal of the elements next to collapse, and the reconstruction with the same technology – in masonry – with calcium mortars. On the façade, he proposed steel ties[80], rotated according to the horizontal plane, and linked to the structural walls. In this case, the ties were linked not on the entire façade, but from the north tower [81] to the window of the southern one; the reason for this choice, probably, was that the southern tower, built few years before, was considered stronger, in comparison to the other, and so more "trustable".

Fig. 4.35 - left
Picture of the façade of the church, after the collapses of the interior (TSA)

Fig. 4.36 – right above
Picture of the church before the collapses.

Fig. 4.37 – right below
Picture of painting about the main gate of the church, after the collapses of the interior (TSA)

Fig. 4.38
Picture of the mission of San Jose after the collapse of the dome. (TSA)

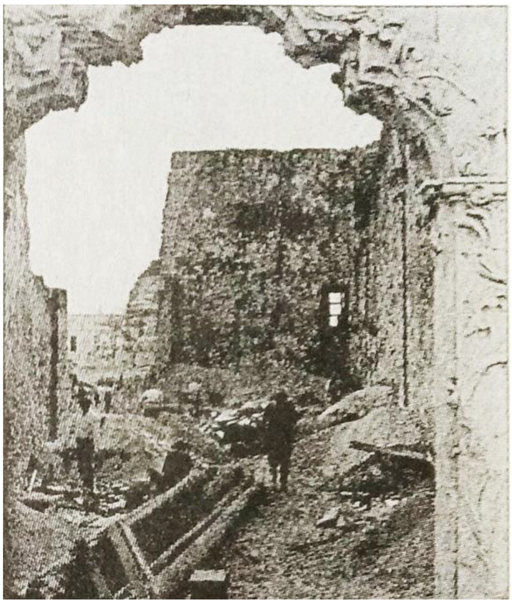
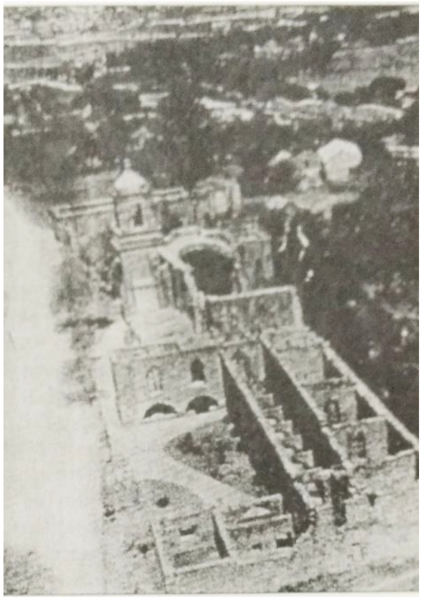



Fig. 4.39 - left
Interior of the church after the collapse of the interiors (Ford Powell and Carson)

Fig. 4.40 - right
Aerial view of the mission with the collapsed church in 1924 (Ford Powell and Carson)


Fig. 4.41 - left
Interior of the church after the collapse (Ford Powell and Carson)

Fig. 4.42 - right
Spectators view the debris of the bell tower that suddenly collapsed on March 9, 1928. (UTSA)

The most complex part of the restoration interested the roofing of the church, with the reconstruction of the vaults and the dome. In this case, the reinforced concrete constitutes the solution to the static problem, with its insertion in different elements, from the foundation level to the top, and different approaches.

In the church was interested by the insertion of a series of coupled columns, with isolating footing on the bases, and linking beams at the ground and the top level, in a way to create independent reinforced concrete frames for each span of the building. In some span, maybe due to the good condition of the walls, the columns were not realized – instead of the lower and upper beams, which were put without the lower support of the columns [82]. The target of the upper beams constituted in the avoiding the weight on the masonry arches, leaving them only the figurative purposes.

The dome had been rebuilt with a complex correlations of elements in reinforced concrete and steel. The supporting structure of the dome, at the walls' height, is made by eight different beams, in a way to form an octagonal support: the longitudinal and transversal beams – which are parallel and perpendicular to the church's walls – are in reinforced concrete, while the other diagonals are realized in mixed structure[83]. This system supports eight small columns in reinforced concrete, above which there is the ring beam – always in reinforced concrete – on which the dome is placed. The coating of the dome is also a slab in reinforced concrete.

Harvey Smith's son described the intervention pursued by his father, showing also how the father considered this restoration as one of the favorites[84].

> *"San José, referred to by many as the Queen of all the missions of Texas was surely Harvey Smith's favorite. […]*
>
> *Having previously restored the Granary, Smith prepared to direct restoration of the main church and convent […]. The main church, with its beautiful baroque façade and baptistery window, was in sad condition. The vaulted roof had collapsed as well as the dome over the crossing. At least three of the walls had partially collapsed. Fortunately, the entrance façade and the beautifully carved windows were intact.*
>
> *Smith was able to replace the roof vaulting and the dome accurately by referring to the fragments of the arches that still remained in place above the spring line. Since it would not be exposed, modern reinforced concrete construction was used for the roof and the dome."* [85]

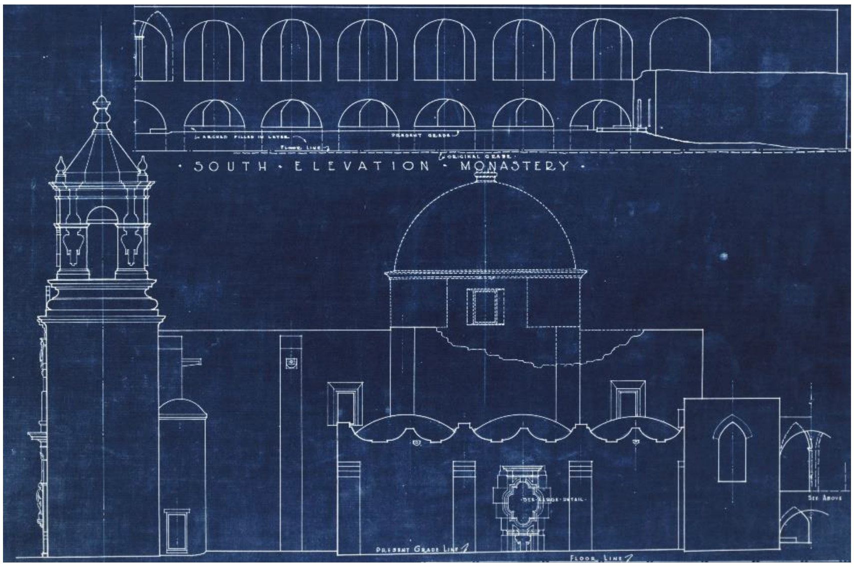


Fig. 4.43
Section drawing with the state of the church after the collapse of the dome and the roof (by Robert Leon White, UTA_AAA).

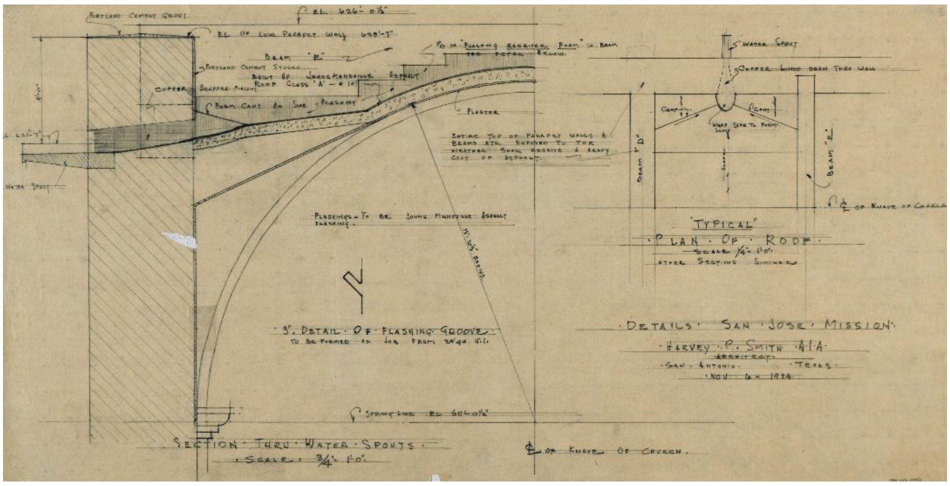


Fig. 4.44
Section drawing of the restoration project by Harvey Smith. Detail of the ceiling vaults in reinforced concrete (1934-1936). (UTA_AAA).

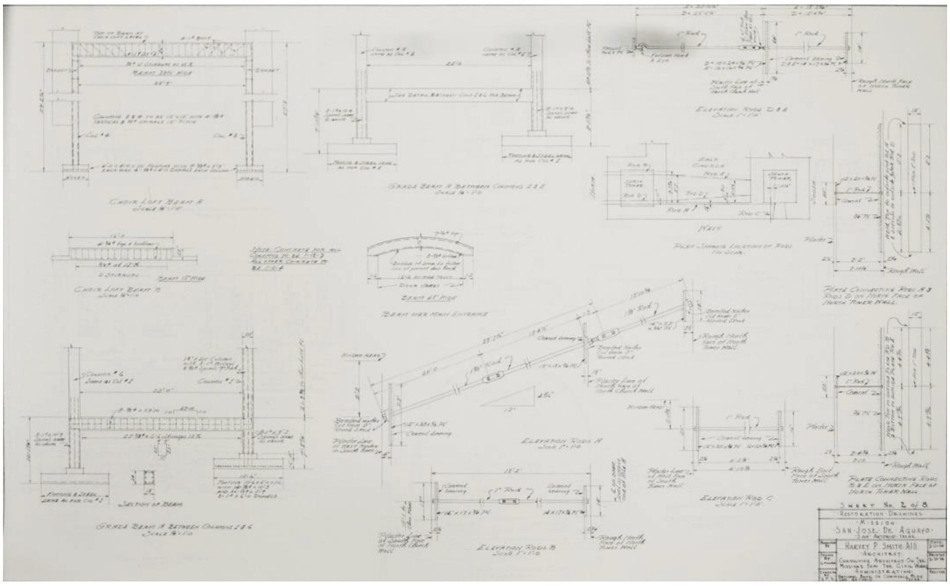


Fig. 4.45
Restoration drawings by Harvey Smith. Details of the elements and frames in reinforced concrete (1934). (NPSSA)

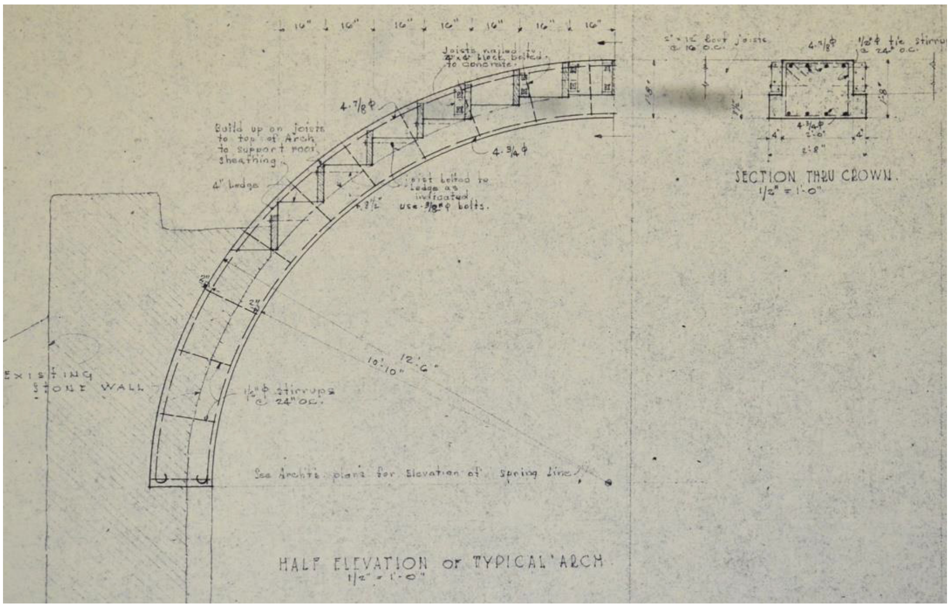


Fig. 4.46
Restoration drawings by Harvey Smith. Detail of the arch in reinforced concrete (1934). (NPSSA)

According to these passages, it is emblematic how the aim of the elements' redefinition by Harvey Smith focuses both in the structural improvement than in the preservation efforts, trying to maintain all the possible elements. Reinforced concrete, also in this case, had been used according to the recommendation of the Athens' Charter, being applied as the structural solution to the main problem of the covering system.

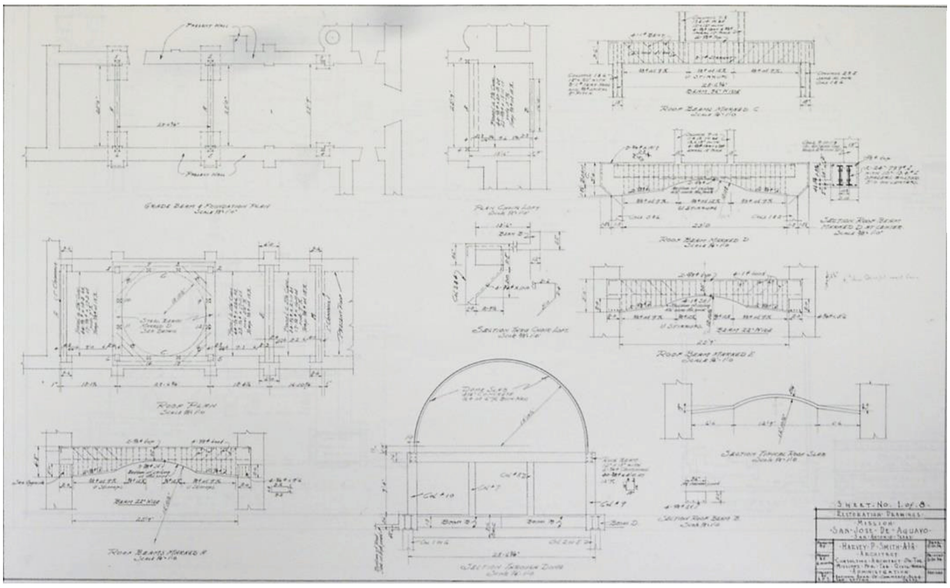


Fig. 4.47
Restoration drawings by Harvey Smith. Details of the elements in reinforced concrete and scheme of the new dome. (1934). (NPSSA)

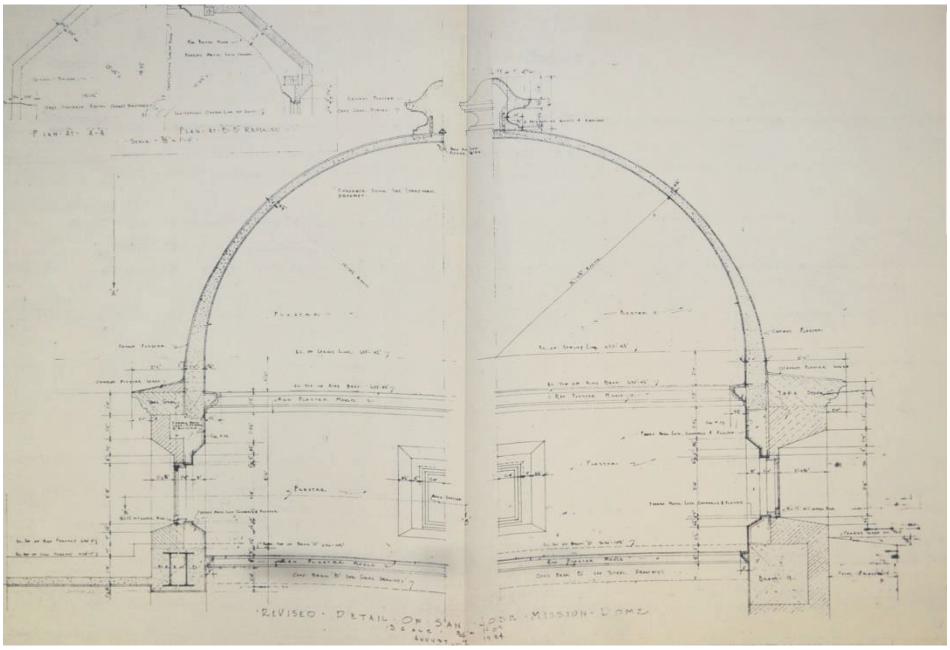


Fig. 4.48
Restoration drawings by Harvey Smith. Details of the new dome. (1934). (NPSSA)

Fig. 4.49 - left
A massive frame scaffold sits beside the church during reconstruction of the tower (April 1928).

Fig. 4.50 – right
Civil Works Administration employees prepare to rebuild the north wall of the mission church, February 1934

Fig. 4.51
Fortified gate constructed by Civil Works Administration employees from plans by restoration architect Harvey Smith, February 1934. It is possible to see the bell tower reconstructed. (UTSA)

Fig. 4.52 - left
Scaffolding covers the entrance to the church while a waterproofing compound is applied to the carved stone façade, (November 1935) (UTSA)

Fig. 4.53 – right
Scaffoldings and works on the dome (1936) (HABS).

Fig. 4.54
Lateral view during the reconstruction of the dome (1936) (HABS)

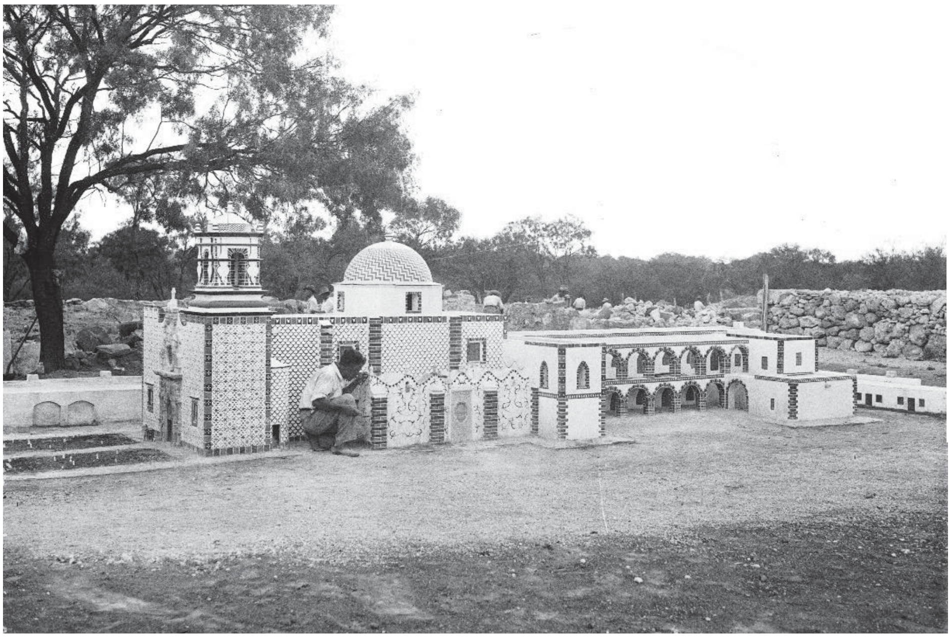


Fig. 4.55
Worker beside the model, painted with reproductions of the geometric designs that once covered the walls of the church and convento, July 1933 (UTSA)

notes

[57] Ivey, 1997.

[58] The first church was built in 1728; years later, in 1744, maybe after a hurricane or with the need of a bigger place, it is documented that another church was going in construction.

[59] The stone portal presented niches and columns, there were two different towers at both sides of the façade, then the interior was single vault nave with a central dome. About the roof there is a hole in the period from the 1762 to the 1772, in which there is certified that the new church did not have its roof; according different theories, this absence could be due to a collapsing in the half of eighteenth century, or it had never been completed (Ivey, 1997).

[60] Thanks to the report of Samuel Maverick, a prisoner in San Antonio at that time, it is possible to know also how was the church: in particular, the colonel Domenigo de Ugartechea of the Mexican army, during the conversion of the building in a fort, decided to demolish the arches with the ribs, and also the vault, for creating an inclined plan to carry the cannons to the top trench (Felli, Ciranna, Lombardi, 2019).

[61] The legendary defense started in February 23rd and stood for thirteen days, since the Mexican troops reclaimed the Alamo and killed the Texan occupiers in March 6th.

[62] After the battle, for many years the Alamo was abandoned as a great tomb. Between July 1850 and June 1851, quartermaster worked to modify the church so that the entire building would provide secure storage for their department. They extended the masonry walls to a uniform height, built the distinctive parapet on the west façade, and installed a wood roof. They constructed a second floor above the entire nave and transept to create a space for a government store that was accessed by a stairway, probably located at the west end of the nave. To provide light to the second story space, they created a system of upper windows.

[63] Also the Valero church, presented some modification since its foundation. Thanks to two different inventories of 1772 and 1793, it is possible to understand that the church did not present the main nave completed in its ceiling, presenting only the ribs of the vaults. The following efforts in the constructions provided the ceiling vaults which, maybe after hurricanes or sample decay, had been interested by remake attempts in 1810. Becoming a fort, the structure of the church had been interested by the insertion of provisional wooden roof only in the 19th century. Changing also its purpose, the building maintained its altered aspect till the DRT efforts of the early 20th century. (Ivey, 2007, Ciranna et al., 2018)

[64] An important organization established in 1891 and dedicated to the preservation of historic sites and the memory of men and women responsible for the Independence of Texas.

[65] The attempt of restoration of the Alamo, freeing the fort also from the privates' possessions, found in the spread and general myth and faith about the heroes of the battle and the religious origin of the building. The DRT leveraged to this common opinion also for their fundraising (Tabor Linenthal, 1988).

[66] Born in May 23rd 1853 in Hillingdon, Middlesex, England, he moved to the United States in 1873 and started to work in the office of Major of San Antonio John H. Kampmann; after few years, he established his own firm in 1876. Even if his activity is strongly connected to the design of courthouses, banks and commercial buildings, he gave his availability to the DRT for the project of the new roof of the Alamo (Hollers George, 2006).

[67] Large part of drawings and reports, probably all of them, are lost. Tragically, the personnel records of the Alfred Giles Company, as well as plans and drawings were lost in an 1892 fire that destroyed Giles' office in the Soledad Block, Houston Street at Soledad. Unfortunately, papers and records of the architectural practice from 1892 to the 1920s were also lost in about 1942 "when vandals and vermin invaded the San Antonio garage in which they were stored" (Hollers George, 2006).

In this case, thanks also to the historical research in the DRT's archive and GLO of Austin, it had been possible recovering some information about the intervention.

[68] Palmer Giles graduated in Bachelor of Science degree in architecture in 1918 at the Massachusetts Institute of Technology. His thesis topic was "The Investigation of the Design of Concrete Water Towers", chosen because "his special interests were water resources and the development of reinforced concrete technology". After graduation, Palmer was named vice-president of the Alfred Giles Company (Hollers George, 2006).

[69] Santa Barbara was the tenth mission to be founded in Alta California when its ministers took possession of the site on December 16th, 1786. Since its foundation, the spaces for the mission had been immediately erected. In December 21st 1812 a disastrous earthquake stroked southern California, causing damages at Santa Barbara. The church after the quake, even if it did not present so much damages, had been rebuilt. Started in 1815, the works finished in 1820. The new church reflected the neoclassicism that was the rage at the turn of the century in both Anglo and Latin America, coming direct inspiration from Vitruvius' Ten Books. Built of dressed sandstone by Indian labor, the Greek temple-inspired church was widened and six engaged columns incorporated. A classical pediment surrounded a niche holding a statue of the patron, Santa Barbara. The façade had been completed with two bell towers, while the interior of the church presents nowadays a single nave with a presbytery raised on few steps.

[70] The church is deeply described also before the earthquake event of 1925 by Lisa Weeks-Wilson (Weeks-Wilson, 1913).

71 From the Los Angeles Times of July 15th 1925 (Augustine Father, 1925).

72 Ross G. Montgomery was an architect, illustrator and historian of architecture and arts. Born in Toledo, an industrial city of the northwestern Ohio on September 26th 1888, he is best known for his designs of new churches and restorations, receiving the commissions of the new church of Saint Ambrose in West Hollywood, the Saint Andrew's Church in Pasadena and the Saint Cecilia's Church in Los Angeles. Defining himself also as a structural engineer, he mostly worked in the fifty years from 1911 to 1961.

73 Montgomery, 1925

74 Ibidem.

75 Ibidem.

76 Ibidem.

77 Adina De Zavala, who is remembered in particular for her efforts in the preservation of the Alamo, interested in the historical architectures of San Antonio, giving particular description of them: in her book about the San Antonio missions (De Zavala, 1917), referred of the visit of Padre Juan Morfi, one of the famous Franciscan historians, who gave a detailed description of the church. *"Mission San José is situated about four miles below the city of San Antonio, not far from the San Antonio River, or as the old records say, "one league from the presidio of San Antonio de Bexas". Founded by Father Miguel Nunez de Abi, under the direction of the Venerable Anthony Margil, who, while waiting at Mission San Antonio de Valero to join the expedition of the Marquis de San Miguel to return to East Texas, decided upon a mission for the Indian thereabouts. The whole building is well proportioned and constructed of very strong calicanto (mixture of lime and gravel) and a rough sand granite, very light and porous, which in a few days solidifies with the mixture, and is therefore very suitable for building purposes. […] The façade is a very costly piece of work on account of the statuary and engraving on it. It is formed of a white stone easily carved. Above the main door a large balcony was built. And it would have a more majestic appearance if a door had been made to correspond to the window which gives light for the choir. No one would believe that such delicate workmanship could be found in such a desert."* (De Zavala, 1917).

78 The northern wall partially collapsed in 1868, and the dome fell in on the Christmas of 1874. The bell tower instead collapsed in March 9th 1928.

79 Part of the restoration y Harvey Smith interested also the Granary of the church, which had been restored with the collaboration of the San Antonio Conservation Society (Batz, 1933).

80 Named "bars" in the drawings.

81 Seeing the façade, the one on the left.

82 The choir and organ areas of the church, positioned on a higher level instead of the entire church, had interested also by the insertion of another linking beam, creating a frame of two different level – ground, first and top.

83 Hybrid section with 2 I-beams in steel and concrete with reinforcement bars.

84 Harvey Smith Jr, 1985.

85 Ibidem.

Chapter 5

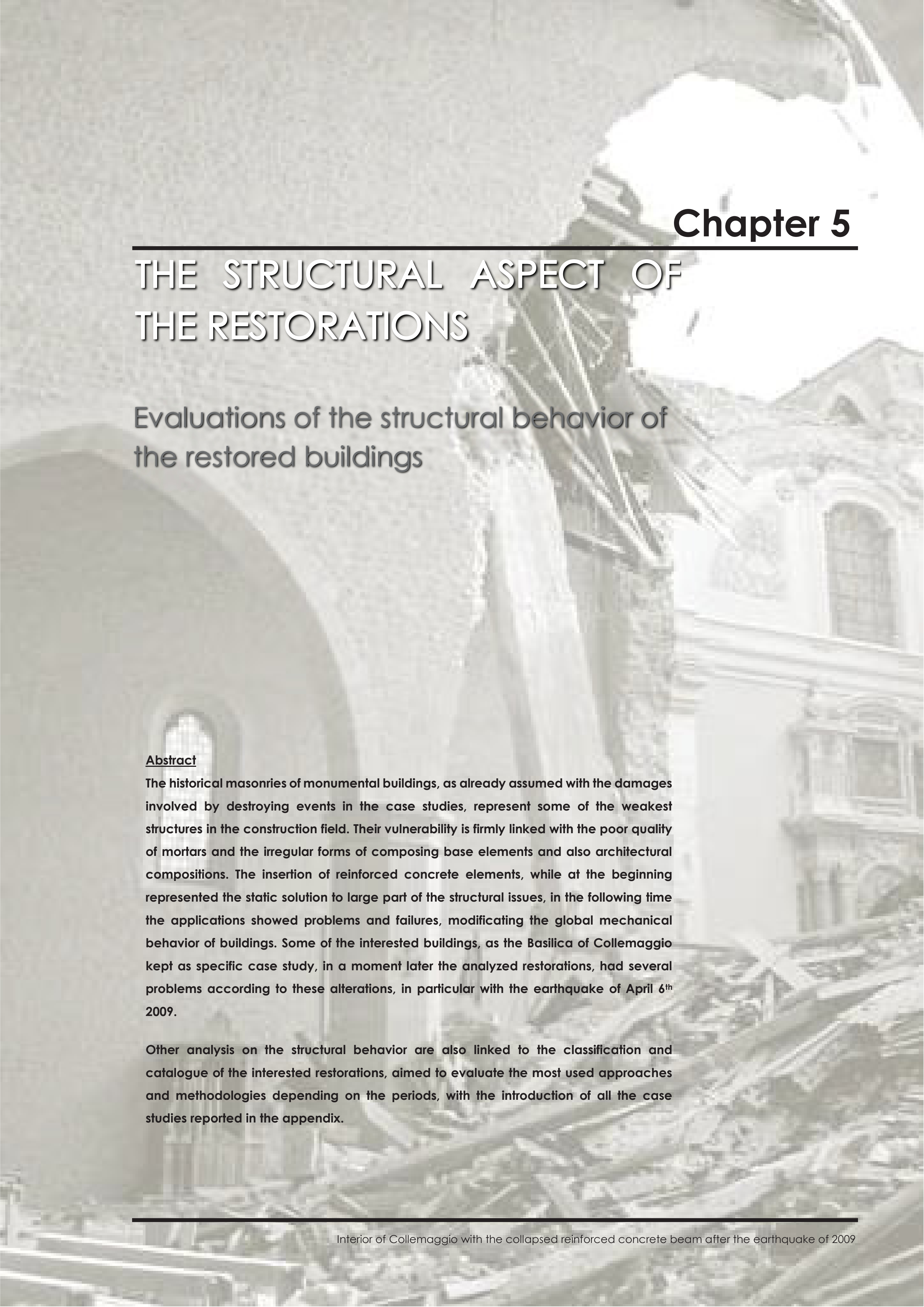
THE STRUCTURAL ASPECT OF THE RESTORATIONS

Evaluations of the structural behavior of the restored buildings

Abstract

The historical masonries of monumental buildings, as already assumed with the damages involved by destroying events in the case studies, represent some of the weakest structures in the construction field. Their vulnerability is firmly linked with the poor quality of mortars and the irregular forms of composing base elements and also architectural compositions. The insertion of reinforced concrete elements, while at the beginning represented the static solution to large part of the structural issues, in the following time the applications showed problems and failures, modificating the global mechanical behavior of buildings. Some of the interested buildings, as the Basilica of Collemaggio kept as specific case study, in a moment later the analyzed restorations, had several problems according to these alterations, in particular with the earthquake of April 6th 2009.

Other analysis on the structural behavior are also linked to the classification and catalogue of the interested restorations, aimed to evaluate the most used approaches and methodologies depending on the periods, with the introduction of all the case studies reported in the appendix.



Interior of Collemaggio with the collapsed reinforced concrete beam after the earthquake of 2009

Capitolo 5

L'ASPETTO STRUTTURALE DEI RESTAURI

Valutazioni sul comportamento strutturale degli edifici restaurati

Abstract

Le murature storiche degli edifici monumentali esaminati, come già dedotto dallo stato dei danni indotto dagli eventi calamitosi a cui gli edifici sono stati soggetti, vengono indicate come tra i sistemi costruttivi a più elevata vulnerabilità per le azioni orizzontali. La loro debolezza, dovuta in larga parte alla scarsa qualità materica, con malte povere e elementi costruttivi differenti per natura forma e dimensioni, viene ulteriormente aggravata dall'irregolarità degli elementi e della forma architettonica. L'inserimento di apparecchiature in calcestruzzo armato, che inizialmente erano poste come soluzioni al problema della statica dell'edificio e sua risposta al sisma, nei momenti successivi all'inserimento sono state rivalutate, a causa dell'insorgenza di ulteriori problemi di natura statica e alla modifica dei comportamenti globali degli edifici. Alcuni dei casi di studio, come la Basilica di Collemaggio, presa come caso di riferimento, hanno manifestato problemi statici con i nuovi eventi sismici, quali, in questo caso, quello del 6 aprile 2009.

Altre analisi sul comportamento strutturale sono invece riferite alla classificazione dei vari interventi di restauro esaminati, con l'intento di valutarne le metodologie più comuni in base ai diversi periodi, e introducendo i casi di studio riportati nelle schede di appendice.

Introduction

"The seismic events constitute an unpredictable and ininevitable catastroph, but they also represent a moment of verify and reflection about the works which had realized during times, aiming to guarantee the safety of the built heritage.

The feature of our territory consists principaly in the large presence of priceless monuments from the past which have arrived to the present day. According their inintrinsinc vulnerability to quake events, these kind of structures must be anayzed with specific akcnowledge and instruments. It is our duty implementing our experience and resources for the safety of this heritage, and leaving in its intact originality to the future generations." [1]

The verifications and the reflections about the works which had realized during times to the historic buildings constitute a necessary starting point in the approach to new restoration interventions. The application of reinforced concrete elements inside the existing buildings, commonly in masonry, had involved also the modification of the entire structures, modifiying the mechanical behaviour which had already been uniformed during the centuries. The analyzed interventions, major part of which are related to building in seismic zones, aimed to give more resistance to the architecures, leaving the structural purposes to the new element instead the original items, which, according to different reasons, were no more able to resist to the vertical and horizontal loads. Their realization, pursued agreeing with the theories of the time and the technological development suggestions, tried to reach all these targets, in a way to transmit the original constructions to the future generations.

These buildings, with the additions, are treated as hybrid structures, comprising masonry and at the same time elemens in reinforced concrete, which necessary influence the structural logic of the architecture with their mechanical characteristics.

The swapping during times of the technological development and the mechanical evaluation about the materials and the structures involved some critic positions about the use of the modern materials in restoration. Also Giovannoni, which had been one of the first promoter of its use in the reinforcement attempt, exaplained how it had been important to have always a global view of the intervention, in a way to do not involve drastic modifications, and so the complete change of the original building into a false.

The quake events of the last decades, as the ones occurred in L'Aquila 2009 and Central Italy 2016, such as the Californian earthquakes in the last decades of the 20th century, constituted a verification test of the interventions realized. Lot of the analyzed buildings in both the areas suffered new damages, in part caused and involved by the reinforced concrete addition. The case studies of some Franciscan missions in California, together with the analysis of the restoration pursued in Italy since the beginning of the 20th century, starting from the Loggia dei Papi to the interventions of the second postwar, try to underline the role of these additions in the mechanical behaviour of the buildings. The basilica of Santa Maria di Collemaggio constitutes in this way one of the most representative restored buildings which sufffered again the earthquake.

Structure of the Chapter

The chapter is divided in four different paragraphs, which intend to reach different aims. In particular, the first paragraph aims to constitute the starting point of this analysis, with the introduction of some structural basics about the masonry and reinforced concrete structures, their behaviour and the reinforcement and conservation's target to reach during the restoration project. In particular, the introduction of the mechanical behaviour of this kind of mixed structure, composed by masonry and reinforced concrete elements, is important in the analisys of the case studies, which are the studied intervention. These buildings are analyzed according to the new earthquake phenomena, which occurred in both areas after the intervention realizations.

The second part aims to show and analyze the impact of the "reinforced concrete restorations" in the mechanical reply to the earthquake stresses, trying to individuate also the correlations among interventions and verified damages; in this part of the dissertation, there are analyzed the damages to some of the studied elements, in central Italy and also in California – Texas, because did not present any earthquake or flooding phenomena in the last years which could involve damages to the structures, is not treated.

The third section considers to analyze a single case study, which is the Basilica of Santa Maria di Collemaggio in L'Aquila, interested by a series of intervetion in reinfored concrete, as also introduced in chapter 3, and which presented several damages and collapses with the recent earthquake of 2009. The paragraph aims to analyse the role of reinforced concrete materials in the structural behaviour of the building and the influence also in the damages.

The fourth paragraph, instead of the first two, represent an introduction to the single analysis performed to the buildings, among the areas of study and the interested period, trying ot identify some common strategies chased according to the typlogies of interventions. The paragraph aims also to introduce the appendix of the dissertation, with the analysis of the reinforced concrete restored buildings.

notes

[1] Luciano Marchetti, from Borri et al, 2011.

5_1

INTRODUCTION

Acknowledge about the study

Masonries and characteristics

The paragraph analyzes the most important aspect to know approaching to structural evaluation of masonry buildings with the insertion of reinforced concrete. Even if the applications of the modern materials constituted innovative solutions in the period of the restorations, today the recent earthquake demonstrated how partially or bad design insertions of reinforced concrete elements inside existing masonry, instead of reinforcement of the bearing walls, constituted a problem to the buildings, which had been interested by several damages. The studies[2] about the masonry structures had been increasingly developed in the last years, starting from the old manuals and treatises since the anquities, as Vitruvio's works, to the 20th century. In the last century, the study of the structural elements started wth the work of Isidoro Andreani[3]. His texts[4] did not present a real detailed study about masonries[5]; however, the work of Andreani had been really important because it was a proof of the lose of the ancient masonry techniques insted of the progressive industrialization of the building process[6].

In Italy, the masonry constructions constitute a heritage which, excluding the different typologies of construction from the second postwar, is represented in large part by interesting and noticeable architectures. Associated to the word "masonry" there are lot of correlated typologies, which identified the production of the materials, the geographical context, the economic and social situations, beyond also the methods of construction. It is necessary to analyze the development of the masonry systems' analysis, focusing in particular on the 20th century approaches to the existing buildings, in a way to understand the logics which involved the applications of reinforced concrete.

In the United States, focusing expecially on Texas and California, masonry structures are not realized in the same way as the italians due to different reasons. As already exposed[7], the franciscan missions were built only since the end of the

18th century, using the acknowledge and experience of centuries of european constructions, reported in the book which the missionaries brought with them. Furthermore, the native did not know the manufactoring of stones and bricks, so they were educated by the friars and the craftsmen of the army to the "contemporary" traditions of constructions. According to the positions of the missions, and also the availability of the materials, the churches were realized with adobe brick, with base mud mortars, on stones foundations, or with adobe and ladrillo – bricks in terracotta with water-isolating properties[8]. Only few of the architectures were also built with stones, requiring more specialized workers[9].

In both the analyzed areas, the structures in masonry had been erected with two main typologies: the masonry composed by two different vestments, with the internal layer filled with mortar and varies debris, and the monolithic constructions, in which the bearing masonry occupyes the entire thickness of the elements.

Structures of the analyzed case studies

The interested buildings of the dissertation present a mixed structure in masonry and element in reinforced concrete, such as beams or columns, which had been inserted during the restoration interventions. Considering that masonry constitutes in large part the main structure of this kind of building, it could be usefull to report some aspects relative also to the masonry seismic behaviour. Masonry is a composite natural material, whose components can be natural or artifical materials, and which exhibit a nonlinear behaviour according to different factors. A single masonry wall subjected to normal [10] and shear actions exhibit a fragile break and also a inadequate duttility, but the seismic answer of masonry buildings is influenced by the characteristics which derived from a complex constructive system, composed of lot of bidimensional elements. The seismic behaviour of a single masonry panel dipends, in the first evaluation phases, from the constructive adjectives and characteristics, which must to be suitable to guarantee a monolithic answer to the vertical and horizontal stresse inducted by the quale. If the art rules are not respected, there can becrumblings of the masonry wall in large parts, or also lot of fissures on the surface[11].

The mechanical characteristics of a masonry panel are related to the composition of the elements, referred to the nature form and size of the elementary aggregates and their anysotropy or homogeneity, the position of the constructive elements and their "weaving", and the regularity of the panel itself. Also, the influence of the global behaviour of the elements can be due to the regularity of the building[12] and the reaching of the "box behaviour", reachable with the correct connections among the masonry panels[13]. According to the typologies of behaviour, a panel can present two different collapsing behaviour inducted by the horizontal stresses, such as the first and the second ways of collapse, individuating kinematic motions. The first motion behaviours are defined also "out of the plane", and they can appear when the element is subject to normal plane stresses. While the second motion behaviours are definied also "in the plane", with the stresses acting in the plane of the panel. The reply to the quake stresses is better when the panels react in their stronger direction, such as in the longitudinal.

Today, the study about the behaviour of buildings in masonry interested by the insertion of reinforced concrete elements constitutes an ongoing research, because of the lot of factores[14] which influence all the evaluations. In this way, lot of the analyzing aspects related to the mechanical behaviour are also taken from the experiences. In particular, there are substantial differences among the use of reinforced concrete elements and their relation with the existing masonry[15].

According to the experiences, the insertion of structural elements in reinforced concrete involves the stiffness increase in the structural reply to earthquake phenomena. Cause of the lack design in the ductility field of behaviour, also the inserted frames presents low values of allowable displacement[16]. Also, it has been observed that the quake reply of ordinary masonry stuctures can be strngly influenced bu the insertion of reinforced concrete elements, causing the increase of the seismic vulnerability. Furthermore, the seismic structural improvement is verified only if all these systems are designed in the ductility field and present also thw capacity of displacement superior than the masonries.

The presence of structural elements of different materials and technology, sometimes also positioned in decentralized in plan, modifies the mechanical characteristics in the distribution of the plan stiffness[17]. In these cases, the alteration of the mass' distribution in the plan[18] involve torsional movements, ununiform shear stresses and stress' localizations in few elements of the structure. Nowadays, it is possible to approach to the existing buildings in different ways and methods, cause also the technological development and the implementation of the existing theories and models, accompanied by also the development of the rules.

In the past, different municipalities undertook different intiatives trying to turn the building activity to the restoration field promoting preservation interventions. However, lot of companies which usually operated in the field of new constructions, started to work in the restoration fields without any education and akcnowledge, with workers not specialized and without any sensibility about the preservation problems. In this way, during the times it had continually increased the tendency to transfer the few-compatible new techniques in the historic centers.

Studies by Giuffrè, Leon and Giovannoni

In this field of reflection about the philosophy of the interventions, the study of the premodern techniques and seismic prevention efforts of the past assumed a primary importance: as observded by Antonino Giuffrè[19], buildings in masonry which had been well designed and maintained had been subjected different times to strong earthquakes, remaining still in their places with a safety level comparable to the modern constructions. The experiences and reflections of Antonino Giuffrè, who critically observed the restoration and reinforcement applications pursued after the earthquake of Valnerina in 1979[20], where the reinforcements of the structures were reached with the applications of reinforced concrete.

The use of reinforced concrete in the historic buildings did not have a global approval: also Paul Leon[21] observed that the insertion of reinforced concrete elements constituted in the application of stiff elements inside elastic structures, involving mechanical imbalances. Also, the inserted elements had been limited in the exterior restitutions, trying to hide them inside, limiting the works to reinforcement in "walls, roofs, valuts, slabs, foundations and buttresses" [22].

According to Gustavo Giovannoni[23], even if the new material let the realization of provisional and definitive reinforcement works, its use had to be limited precautionaly.

> *"In the cities of Sicilia[24] and Marsica hit by the recent earthquaks, it is frequent to see restoration projects of churches in which the arches or naves are interested by the insertion of ties in reinforced concrete, which are not so different from ties in wood. For these monuments, however, the contrast is trully tragic with the original constructive system and the elastic frame structure requested according to the antiseismic rules. Because here, against the revolutionary dynamism from the earthquake, the balance of sources does not count, and usualy the safety let necessary the most arduous sacrifices, according to the experience. […]"* [25]

Gustavo Giovannoni saw the first signs of the problems related to the use of reinforced concrete, while also in 1945 he asserted the risks in these actions.

> *"The limiting of reinforcement works [26] can avoid the alteration of the balances of the building; in this way, the construction can maintain its statics, with which it defended during centuries. Disturbying all these relations and the insertion of a different system of actions can involve the necessity of restart […]*[27].
>
> *So, ad example, among the safety loads and the break loads there is an enormous hap, which is necessary to don't invade in the new buildings, but that is the thick in which the existing buildings live. So, for the old buildings it is necessary to follow the empirical and experimental method, abiding by qualitative evaluations instead of convenctional checks.* [28] [29]
>
> *It is necessary to establish that the mesures to be kept do not try to renovate the building according to the modern criteria, but they must verify if the*

static disturbances occurred during times are not progressiveand then provided maintain his system of balance and help him, not reporting him to our system, which could mean its destruction. This is the essential difference with the method pursued by the Genio Civile in the restorations of monuments. Because of the lack of historical and artistical experties and, also, the lack of responsabilities, they reconstructed or demolished or modified the sections and the resistences of all those elements in which the stability calculations did not respect the limits dictated from the Science of Constructions. Because of one element follows the previous, the definitive result consists in the complete alteration of the monumental building in its authenticity, in its constructive system and in its decorations.

The application of the resistence theories in these cases must be completelly different." [30]

So, even if the additions and the modifications in the restoration works must be undelined with other materials, surfaces, the reinforcement insertion has to be hidden inside the structure, leaving the aesthetic aspetc primary instead the functional. Giovannoni's thought about the restoration can be found in the relative item of the Italian Encyclopedia of Sciences, Literature and Arts by Treccani. The item "Restoration"[31] was wrote in the second half of the Thirty years. Giovannoni appeared to his contemporaries as the natural continuer of the intellectual path traced by Boito and Beltrami, so as supporter of the philological restoration. In true, his position is more soften: he is for the preservation and the limit numbers of interventions, but the real target is the historical acknowledge of the building [32]. Only different years later, there were started the first critic observations about the impact of these applications on the historical existing heritage, trying also to evaluate the real efficiency of these applications, which started to present decaying phenomena. As for example, the International Conference of Lucca [33], occurred in 1981 – 50 years after the release of the Athens' Charter– represented one of the first attempt of report of fifty years of exploration and experimentations about the use of reinforced concrete. With the conference, the most important aim was focused on the necessity to understand the complex relation among science, techniques and restoration [34].

Actual question on the modern means

However, only the seismic events of the last years brought less certanties on the effective efficacy of those restoration intervention of reinforcement which transformed the masonry buildings in hybrid situations, with a mixed behaviour inducted by the historic masonry and the reinforced concrete (or steel) frames, with all the incoherences, the incompatibilities and the larger problems emerged.

One example of the weak behaviour of these intervention could be found in the use of top beams on masonry walls; in these cases, the added elements were not able to transmit the horizontal actions to the bearing walls, neither also to contain the masonry below, which is free of rotate and overturn to the exterior. In consequence, the behaviour of these buildings, instead of the waited shear stresses,

The simple idea that top beams, slabs, injections and plasters in reinforced concrete can reinforce the existing structures in masonry must be considerated wrong, according to the experience and the different evaluations about the materials. The heavy interventions and hybridizing involve the loss of the authenticity of the building, modifying so the structural concept. Furthermore, if the reinforcement intervention is not pursued glabally, interesting all the elements which compose the building, there could be dangerous incongruities among the parts (or the buildings) with very different stiffnesses and resistences.

Even if in all the analyzed restoration interventions the purpose of the application of reinforced concrete had been remarkable, sometimes the structural intention of improvement had been demonstrated not reached with the following events which interested the restored architectures. According to the development of some of the analyzed building, it is possible to remark how this kind of intervention, with the insertion of reinforced concrete, constituted also aggravating elements in the right behaviour in case of earthquake, for example.

This aspect emerged also in the earthquake of Umbria and Marche in 1997 [35], in which there have verified lot of collapses of masonry buildings interested by antiseismic recent interventions. The most important recent quake events, one of which could be the recent event of L'Aquila, occurred in April 6th 2009 [36], represented also the test bed of lot of the restored monuments. Also the Californian area, which is strongly interested by the destroyng quake events which origin from the San Andrea's Fault, presented during times quakes which tested the restoration interventions. According these last cases, two of the analyzed Franciscan missions suffered damages with other destroying events.

notes

[2] In this case the existing bibliography about this kind of studies is varied. Among them, the research based on national reference books and PhD dissertations (Cf. Borri et al, 2012; Lucibello, 2014; Cortesi et al., 2020).

[3] Andreani, 1917.

[4] Ibidem.

[5] Borri et al., 2011

[6] Indeed, all the treated masonry types in the book are the bricks, instead of the oldest used elements (Ibidem).

[7] Cf. Chapter 4, paragraph 4.1 Franciscan Missions: introduction.

[8] The materials used in the construction of the mission buildings were in general adobe, boulders, sand-stone, lime-stone, woods of various kinds, burned tiles and bricks, mortar. The boulders were, where used, generally employed as foundations for the adobe walls. The adobe bricks and blocks were used in various ways. Sometimes, different materials were combined in interesting solutions (Newcomb, 1914).

[9] Newcomb, 1914; Sewall, 2013.

[10] Normal actions represent stresses which are applied in the orthogonal direction of the plane of the object

[11] Usually, the first step to carry out for the interventions affect the verification of the monolithic behavior of the masonry panels.

[12] The characteristics which can influence the right behavior and alter the regularity of the building can be the geometrical differences of the transversal bearing walls (including also their huge spam among them), the excessive thinness of the elements in relation to their height, the disequilibrium and lack of balance among the center of masses and center of stiffness (cf. Cortesi et al., 2020), the presence of masonry panels "in false" or not aligned from the foundation to the top, the not aligned openings (Cortesi et al., 2020).

[13] The box behavior can be influenced by the good quality of the vertical connections of the transversal walls, good caliber of the links between masonry and slabs, high level of stiffness and resistance of the slabs (Ibidem).

[14] Related to the nature of the materials, their qualities, and also the relations with the added elements. Also, the typologies of reinforced concrete structures can deeply influence the behavior of the buildings.

[15] Single elements of reinforced concrete used auxiliary to the bearing walls, as top beams, must be studied differently from the insertion of global frames: the structural differences are related to the main behavior of the building. With the insertion of single elements, the structural behavior is due to the masonry structure, instead of the insertion of frames, which involve also the mechanical behavior of the buildings.

[16] Cattari, Lagomarsino 2013.

[17] As an example, the presence of walls or frames in reinforced concrete, instead of masonry bearing walls, involve the rotational movements of the global structure.

[18] with the consequential plan irregularity.

[19] Antonino Giuffrè was born in Messina in January 17th 1933; he was engineer and professor. Between the 1976 and 1980, when strong earthquakes interested the areas of Friuli and Irpinia, Giuffrè started the first studies and analysis on the historical constructions, based on the quake effects on the structures. From 1984 he begun the study on the historic cities, whose results had been reported in the "Codice di pratica" (Code of practical), which had been experimented in the years later. One of the considered most innovative aspect of the code consists in the consideration of the artwork the primary reference of the structural restoration, whom the other aspects of the restoration intervention, such as the engineering approach, are dependent (Soprintendenza archivistica e bibliografica del Lazio, 2017).

[20] The earthquake of Valnerina, called also the earthquake of Norcia, stroke in 1979 and interested a large area of Umbria. Classified with the 5.8 degree in the Richter scale and IX Mercalli, the quake event interested in particular the city of Norcia, causing 5 victims and damages to the built heritage.

[21] Paul Léon, born on October 2nd 1874, was a member of the Institut de France, Director General of Fine Arts, professor at the College de France. He was the main historiographer of the French Historical Monuments service.

[22] Leon, 1917.

[23] As already introduced in the previous chapters.

[24] Also, Sicily had been interested by strong earthquakes, such as the one of Messina Reggio of 1904, which involved serious damages to all the built heritage.

[25] Giovannoni, 1929.

[26] In a way to reach at least the minimum of the requested performance.

[27] A comparable approach is worth of the use of structural evaluation for historic buildings. The application of the same calculations from the Science of Constructions, as in the case of new constructions, represent the failed comprehension of the requirements of these calculations and also the lacking consideration of the “historical tests accomplished by the times”. The resistance theories have been made for the future buildings, and not for the existing ones; they consider the eventualities of bad constructions, of discontinuities and of crumblings of the structures, which are already predicted in the case of existing buildings.

[28] Giovannoni, 1929.

[29] Some years later, also the Venice charter asserted that when the traditional methods and techniques revealed inadequate, the reinforcement of a monument con be guaranteed also with the insertion and auxiliary of all the modern means.

[30] Giovannoni, 1929.

[31] Restauro.

[32] On this ground, a heated controversy broke out between Giovannoni and Adolfo Venturi (1856-1941), one of the founding fathers of the history of art in Italy. In a volume relating to the architecture of the sixteenth century, Venturi, applying the method of the art historian, analyzes the prospects and formal details of the architecture of the period; Giovannoni signs a controversial review, in which he stresses that architecture must be understood as an organism, that is, conceived through the relationships between the plan, elevation and section. It is precisely the conception of architecture as a space and no longer as a surface or an object - according to Giovannoni - that must characterize the work of the architect and architectural historian. In addition, the building must be studied not only in space, but also over time, or in its transformations, modifications, additions and everything that contributes to the growth of the building organism.

[33] “Il restauro dei monumenti e il ruolo del cemento. Risultati di un’indagine e prospettive future” (“The monuments’ restorations and the role of reinforced concrete, Results of a survey and future prospects”).

[34] In the final considerations of the conference, Renato Bonelli tried to analyze this complex relationship among the different fields, in which it could be useful to identify the limits and autonomies of the contact points of sciences and techniques with the restoration and preservation areas, in a way to create a historical and critic awareness. It is not the case of unification of techniques and scientific research with only functional purposes, according to a point of view that can be considered legitimate and indispensable, but it is the case to orient all the research fields to only one target, which is the result of autonomy and equal importance researches. With this kind of approach, the intervention can be oriented in a serious way. According to Salvatore Boscarino, the restoration – considered as the meeting point of history and techniques, in which historical-critic and artistic-aesthetic aspects cannot be considered independently from materials, structures and preservation problems - must be performed based on the historic and technical aspects at the same time and with the same importance. In this middle way, reinforced concrete represents one of the possible technological solution which can respect and maintain the historic aspect preserved.

[35] The Umbria and Marche earthquake occurred in the regions of Umbria and Marche, central Italy on the morning of September 26th. Preceded by a foreshock almost as strong as the main quake, the main shock was 6.0 degree in Richter scale. The earthquake caused 11 victims and diffuse damages to the built heritage and to the precious art treasures of the areas. The earthquake represented one of the turning point in the upgrade and modernizations of the existing anti-seismic laws in constructions, bringing the first evaluation of the first requalification of the seismic risk in the national territory.

[36] The earthquake of April 6th 2009 hit the entire city of L’Aquila, being felt in lot of areas in central Italy, and caused 309 victims, becoming the deadliest earthquake to hit Italy since the 1980 event in Irpinia. The event had an intensity of 6.3 degree in the Richter scale and it provoked diffuse damages and collapses in all the interested areas; large part of the historical buildings was hit seriously by the event and lot of them had severe collapses. Still today (2020) the reconstruction is in progress.

5_2

IMPACT OF THE RESTORATIONS

Evaluations of interventions based on the later status of buildings

"The methods and intervention technologies for the restoration and reinforcement of the existing historical heritage must present an approaching logic which respects the preservation efforts and consider the safety problems. In this direction, it is possible to considere ourself not as simple heirs but custodians of what we received from the past and that we need to restitute intact."[37]

According to the damages involved with other earthquakes occurred after the interested restoration, it is possilble to understand the behaviour and make some evauation on the structural resistance. Even if there was the intention of make surviving the original parts of the building, aiming to give them more durability with new techniques and materials – which are presentud trustable even if they are experimental, and so untrastable – the experience demonstrated how, with after years, there could be problems of material incompatibility, reaching the standpoint that the new insertios, if they are not removable and so reversable, can involve more static damages to the building [38].

Impacts on Italian restorations

After the inserion of the modern element in the Loggia dei Papi in Viterbo[39] (A_4|1), in 1956 the Genio Civile signaled to the Soprintendenza of Lazio the static problems appeared:

"From tests performed on the trabeation of the Loggia dei Papi, it had been discovered a beam in reinforced concrete relatively recent, whose role of avoidig the whole weight on the columns seems stopped." [40]

Later, it had been realized also an appraisal, trying to add the works on the loggia to the existing recovery project of the cathedral; the project provided the deassembling of the eleents and the realization of a new beam in reinforced concrete. The Superintendent Calro Ceschi, who received the proposal, rejected the interventions.

> *"This binding necessity (the construction of the new beam) does not exist, because the architectural element of interest does not present damages or disabilities such as to let an intervention so demanding […]"* [41]

Only in the Eighty years the loggia had been interested by interventions aiming to limit the instabilities due to the insertion of the reinforced beam; the loggia presented numerous fissures to the columns due to the "excessive load on the trabeation". In 1983, the superintendent Giovanni Di Geso committed more tests on the structures, entrusting the restoration works to the company Fondedile S.p.A..

Oher historic monuments presented damages with the more recent earthquake, such as the one which hit L'Aquila in April 6th 2009 [42]. The main flaw of these types of constructions consists in the crumbling of aggregates from mortars, as the result of cyclic repeated actions, before showing the typical behaviour of the macro-element motions[43]. In the case of the quake event of 2009 it must be considered also an aggravant element, which is the presence of vertical huge elements[44], which repeteitly compressed and decompressed the below masonry, letting in this way the deassemblation of the masonry elements[45]. In particular, the basilica of Collemaggio (A_1|1, A_1|12, A_1|29) – which will be analyzed in the following paragraph – together with other important buildings of L'Aquila, such as th Basilica of San Bernardino (A_1|11), the Cathedral of San Massimo (A_1|10), were not the only interested buildings with several cracks. The damages presented also in other buildings which were interested by reinforcements in reinforced concrete. In particular, the basilica of San Clemente in Casauria (A_1|2), restored by Gavini[46], presented damages which involved the necessity of new reinforcements and the restoration. In particular, the documents of the state of the damages to the building expressed the collapse of part of the ceiling and vaults above the ambon of the church[47].

Fig. 5.1
Sketch which accompanied the letter to the superintendent about the necessity of intervention on the Loggia dei Papi in 1956.

Fig. 5.2
Damages on the Castle of L'Aquila after 2009 quake event. The top beams pushed out of the plane the masonry.

Fig. 5.3
Cathedral of San Massimo after the quake event of 2009. After the collapse of the dome, there is still present the top beam in reinforced concrete.

Fig. 5.4 – Fig. 5.5
Cathedral of San Massimo after the quake event of 2009. Removal of the hanging elements in reinforced concrete.



Fig. 5.6 – left
Mission San Miguel Archangel in 1936.Front Façade (HABS).

Fig. 5.7 – center
Mission San Miguel Archangel after the earthquake of 2003.

Fig. 5.8 – right
Mission San Miguel Archangel today (2019).

Fig. 5.9
Mission San Fernando Rey in 1880.

Fig. 5.10
Mission San Fernando Rey in 1936 (HABS)

Fig. 5.11
Mission San Fernando Rey today.

Impacts on American restorations

In California, lot of the analyzed missions showed some "problems" years later the restoration works, in particular with the tests offered by new quake phenomena.

The mission of San Miguel Archangel (B_2|4),whose restoration had been pursued in 1934, directed by Jess Crettol, had been interested by a renovation interevtention. The static improvement of the buildings consisted in the insertion of reinforced concrete elements, as bond beams and columns, inside the existing system in masonry. The church had been recently interested by an earthquake which occurred in December 22nd 2003 [48] in the central area of California. Instead of some experts asseted to be surpirsed by the surviving of the mission, the church did not show the hoped behaviour in case of new quakes, and presented several damages, with walls pulled apart, statues broke into pieces and a crack appeared that runs the length of the church[49].

Tina Foss, an official with the California Missions Foundation, describing the state of the church after the earthquake event asserted that:

> *"San Miguel is the only mission with original paintings by Munras, They cover the entire inner wall of the church. This is not the kind of building where you can say, 'Oh well, we'll build a replica.' You can never replicate this building.*
>
> *It was the only mission that I felt was in danger of being loss prior to the earthquake. The fact that it's still standing after the earthquake.*
>
> *I haven't even entertained the thought that we won't save the building. Absolutely, it can be saved. The issue is finding the money [50] in time to save it."* [51]

The seismic retrofitting was completed on the convento's side and other quadrangle structures; work on the church building was initiated in 2008 by international seismic and conservation experts, who tool measures to protect also the painted plaster from the seismic engineering work itself.

Also mission San Fernando Rey (B_2|5) presents another case of restored building which had been interested by earthquakes occurred after the restoration. The mission, whose restoration efforts started in 1916 with the first fund-raisers, had been restored only in the Thirty years[52], became rededicated in September 7th 1941.

Years of faithful restoration were laid waste in the early morning of February 9th 1971, by the devasting Sylmar earthquake[53]. With the eartquake, the damages to the existing buildings were different because of the different times of realization, before or after the Los Angeles Building Codes of the 1933 [54]. With the event, damage to the church was deemed irreparable, and the building was red taged for demolition; the massive walls were battered down and hauled off the site. The church was replaced with one of reinforced concrete, faithfully followinf the old design. The convento, however, was approved for restoration, and great care was taken to preserve as much original fabric of this last mission building as possible[55]. The completed complex had only a short reprieve: on January 17, 1994, the Northridge earthquake inflicted extensive damage to the veteran convento building: the new church, built to withstand earthquakes, rode out the peril without mishap. This temblor inspired a through seismic retrofitting of the convento, enabling it to urvive future seismic upheavals. And the re-creation of the historic wall paintings ensures that San Fernando Rey will remain famous for its vibrant interpretation of these rare neophyte decorations [56]. In this case, the insertion of columns and beams in reinforced concrete, without any reinforcement of the masonries involved the collapse of the building. However, after the happening of the seismic events of the Seventies in California, as the Sylmar earthquake, the Office of Administrative Hearing established the necessity of higly rigid seismic stregthening systems [57] encouraging the use of top beams[58].

Also in the analyzed Texan case studies, the insertion of reinforced concrete provided necessary works in the years after the intervention. For example, the Mission of San Josè y San Miguel Aguayo (B_1|3) suffered some fissures due to the increase of weight from the dome, being interested by other interventions from 1947 to 1952. The other reinforcement intervention, carried by Ford Powell and Carson[59], aimed also to recover and stabilize also the rising damp.

notes

[37] Borri et al., 2011.

[38] After all, also, for the put in work of elements in reinforced concrete, it had been necessary disassemble and reassemble all the pieces; however, these operations in theory compromised the integrity and authenticity.

[39] Cf. chapter 2, paragraph “Before the rules”.

[40] Valtieri, 2005

[41] Ibidem.

[42] Cecamore, 2015.

[43] And also before the achievement of the maximum limit of static mechanical resistance.

[44] Such as ceilings, large section top beams and other covering systems realized in reinforced concrete, with their heavyweight.

[45] Borri, 2010.

[46] The restoration intervention by Gavini on the Basilica had been analyzed in chapter 3.

[47] Which is close to the interested part of the previous restoration.

[48] The 2003 San Simeon earthquake struck on the Central Coast of California, about 7 miles (11 km) northeast of San Simeon. Probably centered in the Oceanic fault zone within the Santa Lucia Mountains, it was caused by thrust faulting and the rupture propagated southeast from the hypocenter for 12 miles (19 km). The most violent ground movement was within 50 miles of the epicenter, though the earthquake was felt as far away as Los Angeles. With a moment magnitude of 6.6, it was the most destructive earthquake to hit the United States since the Northridge quake of 1994.

[49] By John Johnson, from Los Angeles Times, February 16th 2004.

[50] The small size of the San Miguel community, 1,100 people, complicates the task of raising money for repairs. Mission foundation officials said they had not seen an increase in giving after the earthquake.

[51] By John Johnson, from Los Angeles Times, February 16th 2004.

[52] Thanks also to the efforts of Father Charles Burns and the backing of Mark Harrington, curator of the southwest museum of the mission.

[53] Epicentered in the foothills of the San Gabriel Mountains in southern California. The unanticipated thrust earthquake had a magnitude of 6.5 on the Ms scale, and a maximum Mercalli intensity of XI (Extreme). The event was one in a series that affected the Los Angeles area in the late 20th century. Damage was locally severe in the northern San Fernando Valley and surface faulting was extensive to the south of the epicenter in the mountains, as well as urban settings along city streets and neighborhoods.

[54] There are lot of documents about the impact of earthquake in Jennings et al. (1971 and 1973) and Housner et al. (1977).

[55] The art historian Norman Neuerburh dedicated himself to repainting many of the original murals on the restored wall surfaces.

[56] Kimbro, 2003.

[57] Also already established in the previous codes with the necessity of columns' insertions supporting the roof (from Sanchez, 1989).

[58] Taken from the guidelines released by the Department of General Services in the State Historical Building Code of 1985 (from Sanchez, 1989). The use of top beams was also accepted by the historians thanks to the lower destruction and removals of the historic masonries from the existing buildings.

[59] Ford Powell and Carson, 2003.

5_3

CASE STUDY: BASILICA OF SANTA MARIA DI COLLEMAGGIO

Structural considerations about the conducted restorations

Earthquake effects

This part of the chapter aims to analyze a single case study, which is represented by the Basilica of Santa Maria di Collemaggio in L'Aquila, interested by the serious earthquake of April 6th 2009. The church suffered the quake event with several damages to its structures, with the collapse of the entire transpet and spread cracks and fissures. According to the restoration intervention of which the building had been interested, the paragraph intends also to analyze the effects of the structural modification inducted by the previous works with the earthquake damage[60].

"The damages suffered by the basilica may be classified in collapses and cracks. The dome and the triumphal arch collapsed by the intersection with the transept; the collapse of the concrete dome was due to the recurrence of multiple causes, among which, in addition to the poor quality of the material of the pillar, to the presence of concentrated actions from the nave walls, which induced the labiliity of the triumphal arch itself. Out-of-plane mechanisms, exhibited by the masonry macroelements, caused instead significant cracks: the overturning of the façade from the lateral walls, the flexural behaviour of the Holy Door wall.

Further signs of structural suffering emerge from the crushing of the quare ashlar masonry of the nave columns, due to the heavy compression induced by the vertical and horizontal acceleration components of the 2009 earthquake. In general, the *damage mechanisms observed in façade and lateral walls could be ascribed to the flexural behaviour due to out-of-plane mechanism, inadequate interconnections among the resistant structural parts as well by as to poor mechanical properties of historical mortars."* [61]

Damages due to restorations?

The collapse of the church finds in complex correlations of elements and behaviours the main reason. The description of the damages of which the Basilica suffered in 2009 displays, among the diffuse damages due also to the poor quality of materials, the impact of the restoration works pursued in the building during times, from Gavini's and Biolchi's (A_1|1) to Genio Civile's (A_1|12) and Moretti's (A_1|29) projects[62]. The numerous available data let the comprehension of the collapsing behaviour of the transpet, invovled by the main shake with longitudinal polarizing motion through the main axe of the church. The performed analysis in linear and non linear evaluations underlined the marked change of stiffness and resistence along the longitudinal axe of the basilica, from the thin walls of the main nave to the thick walls of the aisle through the connection arches among these elements, supporting the barrel vaults and the dome[63].

Trying to identify the damages according to the restoration intervention, the first aspect to be analyzed is the evaluation of structural behaviour of the façade[64], which also influenced the global behaviour of the entire building[65]. In this case, the entire building had been characterized by a complex dynamic response with the fragmentation of the total participating mass in different modes[66].

The façade, with the addition of reinforced concrete elements designed by Gavini and Biolchi, presented a higher level of stiffness in comparison with the rest of the building; the stiffness difference between the façade and the traspet-frame – composed of the two restored columns and the triumphal arch – resulted in an eccentrity between the center of mass and the center of stiffness. When the centers do not coincide, torsional behaviors are activated, increasing the displacements of the elements – in this case the two columns.

With the restoration pursued by Moretti, the two main columns at the intersection of main nave and transpet were interested by their reconstruction in masonry. Due to the lack reinforcement of the re-built masonry[67], the columns, interested by the stress inducted by the torsional effects, were not able to resist[68].

Also, the other restoration interventions, wich provided the insertion of the concrete beams and the reconstruction in reinforced concrete of the dome, increased the shear and compression stresses to the main walls of the central nave, inducting more damages. In particular, the weight of the dome, which had increased excessively instead of the one in masonry, amplified the vertical effects of the quake, involving the supporting columns to elevate stresses, which probably involve the instabilities and the expulsion of materials.[69]

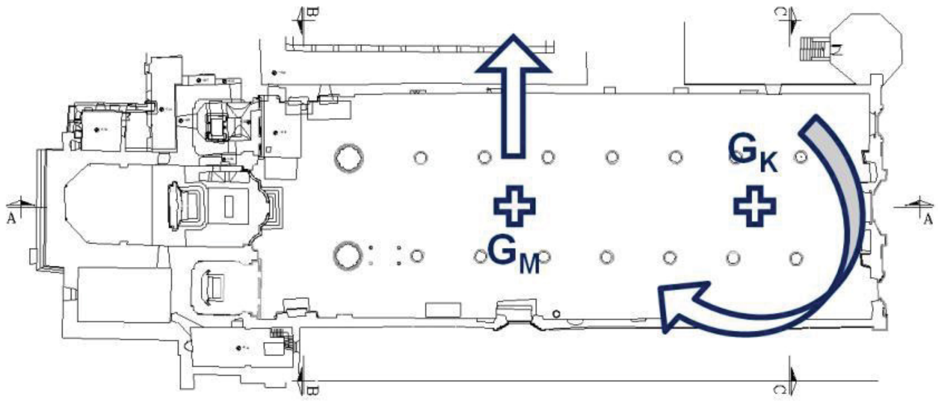


Fig. 5.12
Conceptual representation of the in-plan eccentricity between center of masses (GM) and center of stiffness (GK).

Fig. 5.13 – Fig. 5.14
The collapsed area of Collemaggio with the reinforced concrete elements hanging.

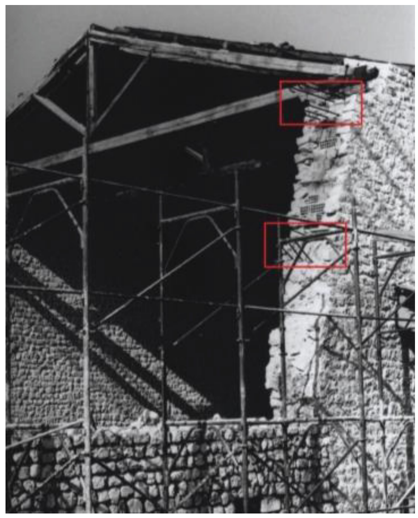


Fig. 5.15 – left
The collapsed transept areas with the hollow elements in the masonry due to the falling of top beams.

Fig. 5.16 – right
The collapsed area of the transept (in the red boxes there are the reinforced concrete top beams).

Fig. 5.17
The remains of the triumphal arch pillar.

Fig. 5.18
The collapsed area of Collemaggio with the reinforced concrete elements hanging and the top beams visible due to the detachment of the plaster.

Fig. 5.20
Interior of Collemaggio with the provisional structures after the earthquake; view from the transept. It is possible to see the top beam in reinforced concrete on the left, at “middle height” of the wall of the main nave.

Fig. 5.20
Interior of Collemaggio with the provisional structures after the earthquake, view from the nave.

The collapse of the main columns of the transpet involved also the “clear cut” of the top beams of reinforced concrete, which collapsed and brught to the collapse other parts of the structure.

The analysis of the collapsing behaviours let the comprehension of the effects inducted with the restoration efforts of the 20th century; also in this case, the use of reinforced concrete elements, without any analysis of the global impact of the additions, involved the complex damage ovierview before explained.

Also, other buildings of L’Aquila, interested by similar interventions, presented comparable reactions and behaviours to the earthquake, with the collapse of the structural element of the transpet. This could be the case of the Cathedral of L’Aquila, the church of San Massimo (A_1|10), which with the earthquake of 2009 suffered the collapse of the transpet and the dome. Both the elements had been interested by restoration intervention in the Fifry years, after the earthquake of 1950[70], and interested the insertion of reinforced concrete elements, which had been literally “expelled” with the earthquake[71] .

notes

[60] Large part of the structural assessment of the church had been realized by the University of L’Aquila, DICEAA (Dept. of Civil, Construction Architectural and Environmental Engineering).

[61] Antonacci et al., 2010.

[62] The structural assessment of the basilica is specific debated in different publications and dissertations (cf. Antonacci et al., 2010, 2012, 2013; Gattulli et al., 2013, 2014, 2015; Borri et al., 2010; Lucibello, 2014)

[63] Antonacci et al., 2013.

[64] Aloisio et al., 2019.

[65] The following analysis and assertion are based on the different models which had been realized for the structural assessment of the church.

[66] Shuttering modes of the structure.

[67] This aspect had been emerged from the damages, with the presence of ruins and bricks around the collapsed pillar, and the poor quality of the used mortar, which involved also the brittle behavior.

[68] Crespi et al., 2015.

[69] Also this is certified by the presence of the exploded material round the columns.

[70] Differently from the event of 1958 occurred in L’Aquila, the epicenter of this event had been in in Fano Adriano (Teramo’s province), involving some damages also in L’Aquila.

[71] This last example, even if the acquired documentation is not enough for the comprehension, can be evaluated from the damages involved by the earthquake. There are some documents relative to the “Restoration of the dome of San Massimo cathedral” in some private archives of engineers. This research is still in progress.

5_4

ANALYZED RESTORATION AND TYPOLOGIES

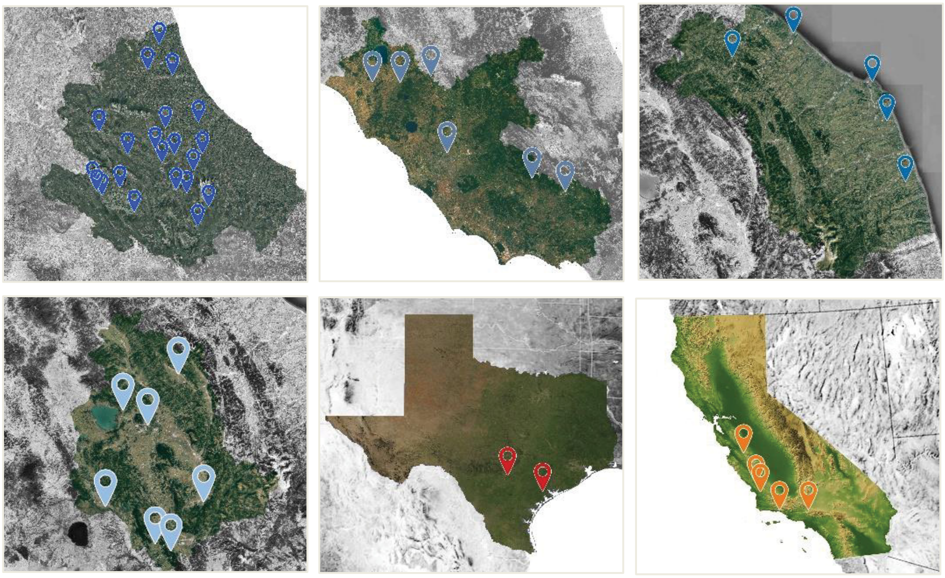
Report of the studied interventions

Forms

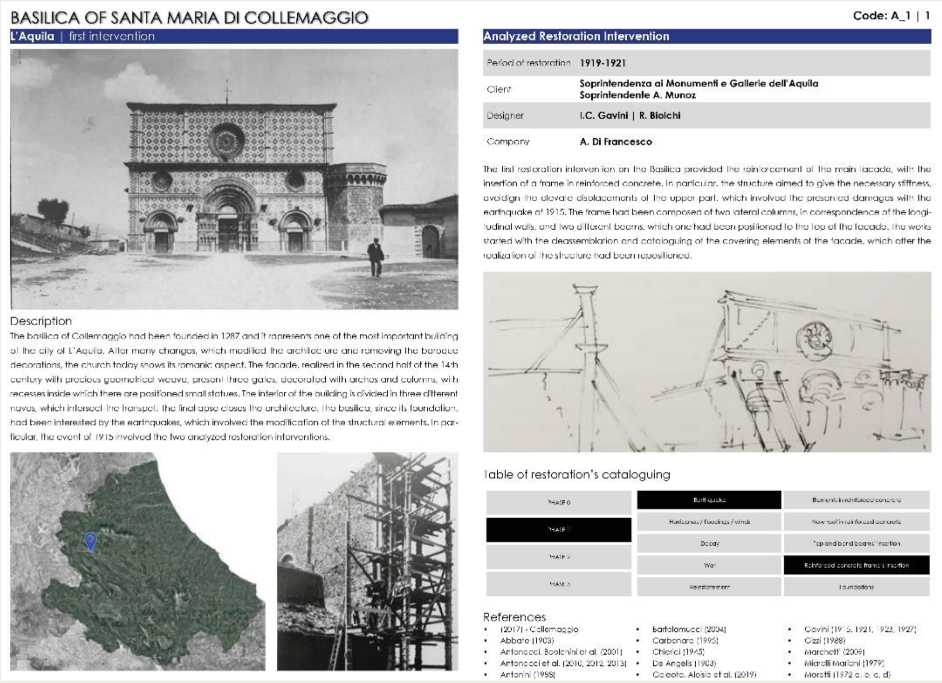
This part of the dissertation introduces the different case studies which had been analyzed[72]. The interventions are divided according to the area of interest, and both the categories are divided also into the local context. The studied interventions had been analyzed according to the periods of restoration[73], to the three phases and reasons[74].

There are individuated about 70 buildings interested by restoration interventions with reinforced concrete applications, among the different areas (Abruzzo, Marche, Lazio and Umbria in central Italy, while Texas and California in the United States).

Fig. 5.21
Individuations of the interventions among the areas of study.
From left to right, top and bottom: Abruzzo, Lazio, Marche, Umbria, Texas and California.



All the information had been reported in the specific forms, which catalogued all the analyzed restoration works.



BASILICA OF SANTA MARIA DI COLLEMAGGIO — Code: A_1 | 1

L'Aquila | first intervention

Description

The basilica of Collemaggio had been founded in 1287 and it rapresents one of the most important building of the city of L'Aquila. After many changes, which modified the architecture and removing the baroque decorations, the church today shows its romanic aspect. The facade, realized in the second half of the 14th century with precious geometrical weave, present three gates, decorated with arches and columns, with recesses inside which there are positioned small statues. The interior of the building is divided in three different naves, which intersect the transpet. The final apse closes the architecture. The basilica, since its foundation, had been interested by the earthquakes, which involved the modification of the structural elements. In particular, the event of 1915 involved the two analyzed restoration interventions.

Analyzed Restoration Intervention

Period of restoration	1919-1921
Client	Soprintendenza ai Monumenti e Gallerie dell'Aquila Soprintendente A. Munoz
Designer	I.C. Gavini | R. Biolchi
Company	A. Di Francesco

The first restoration intervention on the Basilica provided the reinforcement of the main facade, with the insertion of a frame in reinforced concrete. In particular, the structure aimed to give the necessary stiffness, avoidign the elevate displacements of the upper part, which involved the presented damages with the earthquake of 1915. The frame had been composed of two lateral columns, in correspondence of the longitudinal walls, and two different beams, which one had been positioned to the top of the facade. The works started with the deassemblation and cataloguing of the covering elements of the facade, which after the realization of the structure had been repositioned.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and band beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- (2017) - Collemaggio
- Abbate (1903)
- Antonacci, Boolchini et al. (2001)
- Antonacci et al. (2010, 2012, 2013)
- Antonini (1988)
- Bartolomucci (2004)
- Carbonara (1995)
- Chierici (1945)
- De Angelis (1903)
- Coleota, Aloisio et al. (2019)
- Gavini (1915, 1921, 1923, 1927)
- Cizzi (1988)
- Marchetti (2009)
- Miarelli Mariani (1979)
- Moretti (1972 a, b, c, d)

Fig. 5.22
Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila).

The forms are divided into two different parts (pages), trying to identify the building in its reference context and territory and to give concise informations about the analyzed intervention. The first part of the form deals with the general information of the building, with pictures[75], map indications and brief description of the architecture.

Description

The basilica of Collemaggio had been founded in 1287 and it rapresents one of the most important building of the city of L'Aquila. After many changes, which modified the architecture and removing the baroque decorations, the church today shows its romanic aspect. The facade, realized in the second half of the 14th century with precious geometrical weave, present three gates, decorated with arches and columns, with recesses inside which there are positioned small statues. The interior of the building is divided in three different naves, which intersect the transpet. The final apse closes the architecture. The basilica, since its foundation, had been interested by the earthquakes, which involved the modification of the structural elements. In particular, the event of 1915 involved the two analyzed restoration interventions.

Fig. 5.23
Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila). Detail of the first paragraph.

Code: A_1 | 1

Analyzed Restoration Intervention

Period of restoration	**1919-1921**
Client	**Soprintendenza ai Monumenti e Gallerie dell'Aquila** **Soprintendente A. Munoz**
Designer	**I.C. Gavini | R. Biolchi**
Company	**A. Di Francesco**

The first restoration intervention on the Basilica provided the reinforcement of the main facade, with the insertion of a frame in reinforced concrete. In particular, the structure aimed to give the necessary stiffness, avoidign the elevate displacements of the upper part, which involved the presented damages with the earthquake of 1915. The frame had been composed of two lateral columns, in correspondence of the longitudinal walls, and two different beams, which one had been positioned to the top of the facade. The works started with the deassemblation and cataloguing of the covering elements of the facade, which after the realization of the structure had been repositioned.

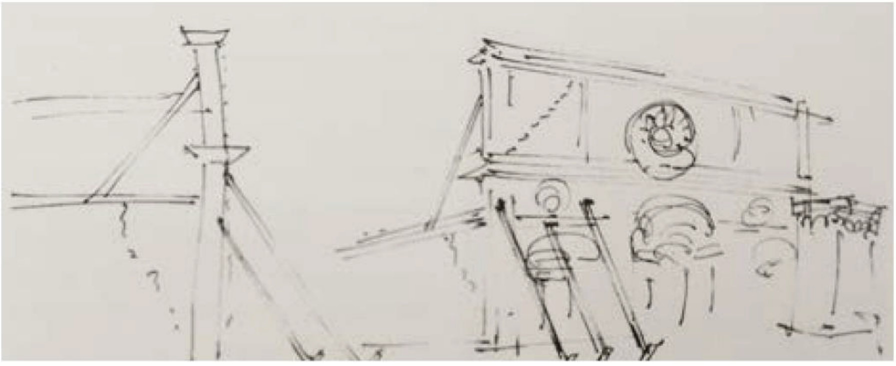


Fig. 5.24
Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila). Detail of the second paragraph.

The second section of the form intends to analyze altogether the interested restoration, specifying all the informations about the period, the designers, the client and the company which realized the intervention. The work is also catalogued in a specific recapitulatory table, in which it is possible to point out the different aspects related to the restoration.

Each column of the table presents the aspects related to the interventions; in particular:

- The first column is related to the period of the interventions, according to the divisions reported in the first chapter of the dissertation: PHASE 0 (aiming to identify the period of the first experimentations, before the Ten years of the 20th century), PHASE 1 (from the Ten years to the release of the Athens' Charter in 1931), PHASE 2 (from the release of the Athens' Charter to the Second World War), and then PHASE 3 (from the second post-war period)
- The second column interests of the reason of the restoration, which, according to the observed and studied interventions, are divided in: EARTHQUAKE (the restoration followed the necessity of reconstruction and reinforcement after quake events), HURRICANES/FLOODINGS/RAINS (as earthquake's cases, but involved by this kind of events), DECAY (in which

the interested building had been restored because of general decay conditions, not involved by destroying phenomena), WAR (buldings damaged by war effects, as direct or indirect bombardments [76]), REINSTATEMENT (in this case there have been catalogued all the interventions aiming to reinstate the original aspects of buildings or elements, and which do not present decay conditions).

- The third column analyzes the typologies of interventions [77], according to the insertion of reinforced conrete elements. Throughly, the interventions interested: ELEMENTS IN REINFORCED CONCRETE (intending the recreation of original elements but in reinforced concrete – as domes, columns, slabs), NEW ROOF IN REINFORCED CONCRETE (with the substitution of the existin roofs in new ones in reinforced concrete – with beams in r.c. and hollow elements, or plates), TOP AND BOND BEAMS' INSERTION (top and bond beams in reinforced concrete inserted in the structure supporting the roofs or the horizontal systems), REINFORCED CONCRETE FRAME'S INSERTION (insertion of frames in reinforced concrete elements – columns and beams), FOUDATIONS (intending all the interventions on foundations with the insertion of elements in reinforced concrete, such as new plates, plinths or foundation beams).

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

Fig. 5.25
Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila). Detail of the recap table.

Case studies

The analyzed restoration interventions concern in particular the following buildings[78], divided for each area:

Case studies in Abruzzo:

1. A_1 | 1: L'Aquila, Basilica of Santa Maria di Collemaggio (1st intervention)
2. A_1 | 2: Castiglione a Casauria (PE), Basilica of San Clemente
3. A_1 | 3: Celano (AQ), Church of the Saints Giovanni Battista e Evangelista
4. A_1 | 4: Magliano De' Marsi (AQ), Church of Santa Lucia
5. A_1 | 5: L'Aquila, Tower of the Municipality
6. A_1 | 6: L'Aquila, Betti Palace
7. A_1 | 7: Celano (AQ), Piccolomini Castle
8. A_1 | 8: Rosciolo (AQ), Church of Santa Maria in Valle Porclaneta
9. A_1 | 9: Alba Fucens (AQ), Church of San Pietro in Albe
10. A_1 | 10: L'Aquila, Cathedral of the Saints Massimo and Giorgio
11. A_1 | 11: L'Aquila, Basilica of San Bernardino

12. A_1 | 12: L'Aquila, Basilica of Santa Maria di Collemaggio (2nd interv.)
13. A_1 | 13: Pacentro (AQ), Cantelmo Castle (1st intervention)
14. A_1 | 14: Pianella (TE), Church of Santa Maria Maggiore
15. A_1 | 15: Carpineto della Nora (PE), Church of San Bartolomeo
16. A_1 | 16: Sulmona (AQ), Church of Santa Maria di Roncisvalle
17. A_1 | 17: Ortucchio (AQ), Church of Sant'Orante
18. A_1 | 18: Pescocostanzo (AQ), Fanzago Palace
19. A_1 | 19: Bussi Sul Tirino (PE), Church of Santa Maria di Cartignano
20. A_1 | 20: L'Aquila, Forte Spagnolo
21. A_1 | 21: Fontecchio (AQ), Convento of San Francesco
22. A_1 | 22: Avezzano (AQ), Shrine of Santa Maria di Pietraquaria
23. A_1 | 23: Celano (AQ), Church of San Francesco
24. A_1 | 24: Capestrano (AQ), Church of San Pietro ad Oratorium
25. A_1 | 25: Serramonacesca (PE), Church of San Liberatore a Maiella
26. A_1 | 26: Teramo, Church of San Domenico
27. A_1 | 27: Sant'Omero (TE), Church of Santa Maria a Vico
28. A_1 | 28: Teramo, Tower Bell of the Cathedral of Santa Maria Assunta
29. A_1 | 29: L'Aquila, Basilica of Santa Maria di Collemaggio (3rd interv.)
30. A_1 | 30: Palena (CH), Ducal Palace (Castle)
31. A_1 | 31: Caramanico Terme (PE), Church of San Tommaso
32. A_1 | 32: Guardia Vomano (TE), Church of San Clemente al Vomano
33. A_1 | 33: Pacentro (AQ), Cantelmo Castle (2nd intervention)
34. A_1 | 34: Pacentro (AQ), Cantelmo Castle (3rd intervention)
35. A_1 | 35: Sulmona (AQ), Former Cloister of Santa Chiara
36. A_1 | 36: Sulmona (AQ), Abbey of Santo Spirito a Morrone
37. A_1 | 37: Sulmona (AQ), Casa Santa dell'Annunziata

Case studies in Lazio:

38. A_4 | 1: Viterbo, Loggia dei Papi
39. A_4 | 2: Tuscania (VT), Church of San Pietro (1st intervention)
40. A_4 | 3: Velletri (Roma), Temple of anta Maria del Sangue
41. A_4 | 4: Orte (VT): Diocesan and Sacred Art Museum
42. A_4 | 5: Tuscania (VT), Church of San Pietro (2nd intervention)
43. A_4 | 6: Tuscania (VT), Church of Santa Maria della Rosa
44. A_4 | 7: Sora (FR), San Domenico Abbey
45. A_4 | 8: Guarcino (FR), Church of San Luca
46. A_4 | 9: Tuscania (VT), Church of Santa Maria Maggiore

Case studies in Marche:

47. A_2 | 1: Ancona, Benincasa Palace

48. A_2 | 2: Fermo (AP), Cathedral of Santa Maria Assunta
49. A_2 | 3: Ancona, Bell Tower of the Cathedral of San Ciriaco
50. A_2 | 4: Ancona, Roman Amphitheater
51. A_2 | 5: Urbino (PU), Palazzo Ducale
52. A_2 | 6: Ancona, Ferretti Palace
53. A_2 | 7: Loreto (AN), Tower Bell of the Basilica della Santa Casa
54. A_2 | 8: Ancona, Cathedral of San Ciriaco
55. A_2 | 9: Pesaro (PU), Rossini Theatre

Case studies in Umbria:

56. A_3 | 1: Perugia, Basilica of San Pietro
57. A_3 | 2: Narni (TR), Cathedral of San Giovenale
58. A_3 | 3: Castel Rigone (PG), Lazzaretto
59. A_3 | 4: Spoleto (PG), Building in Via dell'Assalto
60. A_3 | 5: Spoleto (PG), Cathedral of Santa Maria Assunta
61. A_3 | 6: Amelia (TR), Civic and Archaeological Museum
62. A_3 | 7: Orvieto (TR), Palazzo Papale
63. A_3 | 8: Gubbio (PG); Theatre of the Municipality

Case studies in Texas

64. B_1 | 1: San Antonio (TX), Mission San Antonio de Valero (the Alamo)
65. B_1 | 2: Goliad (TX), Mission Espiritu Santo de Zuniga
66. B_1 | 3: San Antonio (TX), Mission San José y San Miguel de Aguayo
67. B_1 | 4: Goliad (TX), Mission La Bahia (Praesidio La Bahia)

Case studies in California:

68. B_2 | 1: San Juan (CA), Mission San Juan Bautista
69. B_2 | 2: Santa Barbara (CA), Mission Santa Barbara
70. B_2 | 3: San Luis Obispo (CA), San Luis Obispo de Tolosa
71. B_2 | 4: San Miguel (CA), Mission San Miguel Arcangel
72. B_2 | 5: San Fernando Valley (CA), Mission San Fernando Rey De Espana
73. B_2 | 6: San Juan (CA), Mission San Juan Bautista

Considerations

Thanks to the analysis of all the case studies, it had been possibile to make some correlations among the different areas, considering particular aspects related to the restoration interventions.

Among the case studies, about the 25% of them are referred to interventions realized in the first half of the 20th century[79]. Instead, large part of the analyzed interventions (more tha the 70%) interest the phase 3, from the second world war to the last decades of 20th century.

In total, twenty-three of the interventions are refered to earthquake reasons (31%), while only two of them to hurricanes/floodings/rains (in San Antonio and Goliad); thirty-eight different case studies referred to decay conditions (52%); five case studies to wars (7 %); sixteen interventions by operation of reinstatemt and radical modifications (21%). Among them, twenty-seven interventions focused on the substitution of elements (or insertion) in reinforced concrete; seven regard new roof in reinforced concrete; thirty-nine focus in top and bond beams in reinforced concrete; sixteen provided new frames in reinforced concrete; and ten are referred to the reinforcement of foundations.

Thanks to the study of the typologies of interventions, it could be remarkable analyze the reasons of the restorations, which, in the interested areas and in the specified periods, found in the destroyng events, as quakes hurricans and wars, the main reason of interventions[80]. In the first analysed periods, large part of the interventions focus on the insertion of new elements in reinforced concrete, in substitution of structures of the building which left their resistances. The second interested period show how the reinforced concrete had been used as a common mean improving the structural resistance; in particular, large part of of the interested interventions in this phase provided the use of reinforced concrete in lot of applications, from the realization of new structural elements to the insertion as top and bond beams, and also the foundations. Moreover, this phase of the restorations interest the works of reinstatement, instead of natural phenomena or decay.

According to the analysis of the typologies of interventions, related to all the phases[81] , the reinforced concrete frame insertion, also, interested large part of the restorations pursued in the last phase of the analysis: exept four different interventions related to phase 1 and 2, the other twelve restoration studied interventions are referred to the last phase.

Furthermore, large part of the restoration projects in which reinforced concrete applications interest the insertion of top beams and also the foundations are related to the last phase of the work, with the interventions realized from the second post-war. Among the different approaches, the last period of the restorations, from the second world war, interested commonly the specifi approach to the existing buildings with the insertion of top and bond beams in reinforced concrete, supporting the existing/new roof systems.

notes

72 All the analysis is reported in the appendix, in which, with the creation of forms there are individuated the typologies of restoration, the period and all the useful information.

73 Cf. chapter 1.

74 In the report of the intervention the phase 0 is also including, analyzing the interested interventions.

75 The picture, if found, refers to the periods of the analyzed interventions. Also, in the below part of the "left section", there is another image, helpful understanding the architecture.

76 Some of the interested buildings were damaged by the impact effects of bombardments, even if they were not the target.

77 All the interventions can be referred to the global scale of the interested building or to the local scale of the single elements).

78 In some buildings, the analyzed interventions are more than one (it is reported also in the title of the forms).

79 The only building which had been realized before the Ten years is the Loggia dei Papi in Viterbo (cf. chapter 2).

80 Also, there are some cases due to the necessities of reinstatement (for example the restoration intervention of the Alamo).

81 Differently from the last analysis, in which the results are analyzed according to the specific period, and not from the typology.

Conclusions

REINFORCED CONCRETE AND RESTORATION TODAY

Relation and preservation in today's context

Abstract

The actual debate about the relation between reinforced concrete and restoration represent one of the most discuss topics. The past and recent experiences certified the potential risks of the historical construction with these kind of additions; the problem found its origin also in the scarce acknowledge (surely minor than today) and the use of the mean sometimes without any design shaping. The actual problems deal with not only the structural and mechanical aspect, but also the architectural form and the historicizations of the added elements. According this point of view, the critical knowledge of all the related aspects to the restorations become fundamental, and from this perspective also the reinforced concrete solutions can be evaluated as best practices.

The possible additional research can be improved in different field related to the topic: the analysis of other case studies can improve the evaluation of aspects which influence the large use of reinforced concrete in the period close to 30s; additional research can be proposed for the analysis of the intervention relatively to the decay of the "material reinforced concrete". Also, other researches can be developed in the same fields, but referring to the modern architecture and, in general, to the architecture of the last decades.

Interior of Collemaggio with the new columns in reinforced concrete during the restoration interventions

Conclusioni

CALCESTRUZZO ARMATO E RESTAURO OGGI

Rapporto e conservazione nel contesto odierno

Abstract

Il dibattito attuale sul rapporto tra calcestruzzo armato e restauro rappresenta uno degli argomenti più discussi; le esperienze passate e recenti hanno certificato di fatto il potenziale rischio relativo all'apparecchiatura costruttiva storica caratterizzata dall'inserimento di questi elementi; il problema evidenziato trova la sua origine anche nella scarsa conoscenza del tempo e l'uso dei moderni mezzi molte volte senza un adeguato progetto e dimensionamento. I problemi attuali non vertono solamente sull'impatto strutturale e meccanico, ma anche sulla forma architettonica restituita e sulla storicizzazione degli interventi stessi. Da questo punto di vista, la conoscenza critica di tutti gli specifici aspetti relativi al restauro diventa fondamentale, e da questa prospettiva anche la soluzione in calcestruzzo armato può essere rivalutata come strategie migliore in alcuni casi.

I possibili ulteriori sviluppi della ricerca possono essere affrontati nei vari campi connessi al tema di studio: l'analisi di ulteriori interventi può rafforzare le valutazioni sugli aspetti che influenzarono il diffuso uso della tecnologia in c.a. negli anni Trenta; ulteriori indagini sono inoltre possibile per l'analisi degli interventi, ma relativamente al degrado del materiale "calcestruzzo armato". Infine, addizionali sviluppi possono riguardare lo stesso tema, ma riferendosi alle opere architettoniche moderne, fino a quella degli ultimi decenni.

With the analysis of the cases studies, the development of the theories, and also the relations among the area of the study and the use of reinforced concrete additions, the conclusions aims to identify and evaluate the different aspects which still today characterize the relations between reinforced concrete additions and the restoration.

Structure of the chapter

The conclusions are divided in two different paragraphs, in a way to identify the critical aspects and the possibilities of other researches. In particular, the first paragraph analyzes some of the critic observations about the conducted interventions, according to what emerged in the dissertation and, in particular, in the structural evaluations' phase. Comparing with the theories and the development of rules during times, it is underlined how large part of the restorations had been as basis the scientific assertions (which have been modified or completely overturned by the experience, such as the interventions which heavy reinforced concrete top beams, the substitution of vaults with slabs in reinforced concrete, roof in concrete and hollow bricks) dictated from the reference period. It could be also remarkable how strategical choices of improvement interventions must be evaluated according to the historicizing of the interventions, and so analyzed according to the critic evaluations of the theory of restoration of nowadays.

The second phase of the conclusion is focused on the additional developments of researches, divided according to the different scenarios. It could be absorbing to examine other contexts in which, in parallel to the cases treated, reinforced concrete provided an answer to the various needs of structural recovery and restoration - trying to identify and evaluate the various experiments that, in the Thirty years, affirmed their primary role in world scale. The further investigation of the reported case studies, according to the structural and formal impact of the restorations, provides the basis for any investigations aimed at identifying the specific vulnerabilities for each type of restoration, maintaining the assumptions of the specificity of each building and the necessary analysis of the structural construction. A further field of investigation results from the study of the "reinforced concrete material" and from the problems that can emerge over time with degradation, both structural (with loss of load-bearing capacity and resistance) and at a formal level (reactions of cement with lime in the walls).

At the turn of the different framed scenarios, it is useful to deepen the role of reinforced concrete in modern architecture, in relation to its use on a global scale over time, to structural behavior, and to the degradation of the material.

STRATEGIC DIRECTIONS OF INTERVENTION

Critical evaluations and possible direction of interventions

Evaluations on the impact of restorations

With the analysis of the selected restoration interventions, pursued in the last chapter, there could be asserted some evaluations about the interventions, aiming to underline some critical aspects. In this way, it could be useful evaluate all the critical aspects emerged from different points of view; according to the impact of the restoration in the definition of the formal building it is possible to evaluate how this approach to the building can involve also difficulties in the evaluation of the future interventions, due the historicizing of the interventions; the other point of view is focused on the impact of the restorations according to the static point of view, with the damages which the restored building suffered after the interventions.

1. First of all, an important aspect on which it is necessary to be clear is related to the fact that the old restoration interventions were pursued according to the development of theories and technologies, and, of course, the acknowledge about the insertion of reinforced concrete system was completely different from the present days[1]. It must be considered that the realized restoration interventions, in all the analyzed phases, are related to specific theories and laws which, usually, involved specific methodologies of interventions, as for example the use of reinforced concrete top and bond beams found in the necessity of perimetral links of the elements the main reason of its use.

2. Another aspect on which it is necessary to focus on is the indistinct use of reinforced concrete additions to all the possible existing typologies of masonry walls, making no differences among bearing walls in bricks, stones, or in adobes in the American context. The systems had been applied to every kind of masonry and building, with the same approach and "theories" and without any considerations about material nature and

architectural and geometrical form. Sometimes, this last aspect had involved wrong design of top beams, with reinforced concrete elements with excessive height which, in times, involve damages to the below walls – that, according to the seismicity of the place or not, can involve serious damages and cracks, sometimes also collapses as Collemaggio.

After these necessary forewords, some of the most absorbing aspects emerged with the analysis of the case studies, according to the development of the use of this material, can referred to:

3. Use of specific methods of interventions according to the period. As also reported in the last chapter, every phase is characterized by the use of specific approaching methods and typologies of reinforced concrete insertions. The first two phases[2] indicate the insertion of new elements in reinforced concrete which substitute original bearing elements and which are hidden inside the masonry - apart some restoration in which it is possible to see the inserted elements[3].

   The use of specific methods in specific periods had been emerged in particular in the last phase of restoration (phase 3, from the second after-war), which present large part (mostly all of them) of the case studies with the insertion of reinforced concrete top and bond beams.

4. Necessities of restoration in specific periods, as for example large part of the restorations pursued in the defined phases 1 and 2 (Ten and Twenty years of the 20th century) found in the destroying natural and human destroying events (as respectively earthquakes and floods and world wars) the main reasons of the restoration and recovering attempts.

Reinforced concrete and architectural form

Excluding from the moment the structural impact, and focusing only on the formal aspects and restitutions, according to the relation between reinforced concrete elements and original structures, the thought of Giovannoni can be represented as negatively emblematic in this case.[4] The architect in his *Questioni*[5] introduced the problems related to this kind of restorations according his point of view.

> *"Every element of the life of a historical building represent a page of its constructive and architectural history which cannot be suppressed, neither hidden, neither faked. Also the material structure cannot be altered, as in the substitutions, because when the authenticity is missed, every aspect of the certain document and real testimony finish […]. And the restorers won't give false hope for the removals and the additions, neither to take reference from the style and to continue it. The anti-historic restoration will be always an anti-artistic one, and not only it will be make impossible the future*

study of the monument, but also it will make the aspect vulgar and trivial." [6]

Giovannoni persisted on the necessity of avoiding the substitutions, intending them as the alterations of the original structures, with the deassemblation and repositions of the covering elements, letting the insertion of "hidden" elements, such as the reinforcement of walls, roofs, vaults, slabs, buttresses, dodging the visibility of the interventions. In this way, the reinforcement of the restoration must be pursued continually, as a gradual therapy.

"The reinforcement restorations, rather the static reinforcements and defense from the external agents, constitute technical measures aiming to preserve and repair, representing also the most modest intervention of restoration, providing without fantasy but, also according this reason, must be object of the most attention." [7]

In United States, the approach to the buildings in the interested period reproduces partially the thought of Giovannoni in the realization fields: the restoration projects reached in the first period, referring to phase 1, reflect the aim of the structural reinforcement. The improving interventions as the Californian case studies, or the reconstruction attempt pursued in San Antonio in Mission San José (B_1|3) aim to redefine the form, avoiding the "restitution of the concrete element as it is", preferring let it hidden inside the masonry covering. But in the case of the Alamo (B_1|1), the reinstatement attempt reported explicitly the reinforced concrete elements, letting the people understand the new inserted element – the cross and barrel vaults of the interior. Paradoxically, the two case studies are located at the exact opposites in comparison to the theories (Giovannoni's and Athens' Charter)[8].

The impact of the reinforced concrete elements in the restoration projects, intended also as means (solution) aiming to solve the static problems[9], had characterized also the following decades and theories, carrying the positions of the most important theorists. While Giovannoni rejected the idea of deassemblation and reposition of the elements, Brandi asserted the necessities in some cases[10]. Starting from the identification of the restoration topic, rather the "*work of art"*[11], the physic consistency of the work of art must be primary[12].

"The conservation of the additions, historically, must be considered legitimated, while its removal must be justified and made in a way to conserve traces of its existence. The conservation of the addition must be considered regular, its removal exceptional."[13]

And also, Brandi tried to describe the problem of the deassemblation and reposition of the monuments, individuating some special cases in which this approach is allowed, keeping in reference the inalienability of the monument from its context.

> *"The legitimacy of deassemblation and reposition, only related to the safety of the monument as the only solution for its survival, but always and only relatively to the historic place in which it has built."*[14]

The position of Brandi about the restoration project of San Pietro in Albe (A_1|9), which himself considered one of the best performed, during a period characterized by "spreading restorations/falsifications", underlined the necessity of this kind of restorations, the only solution pursuable in seismic zones, after quake destroying events. The debate about the relation between reinforced concrete (globally intended with "structure") and restoration had characterized and continues characterizing the approaches to historic buildings.

> *"The relation among historic acknowledge and the technical-scientific expertises mustn't be considered independent in preservation, even if today there are the reinforcement project and the restoration project as independent entities, which cannot consider independent the architectural and static aspects; also, they cannot be studied separately and merely combined in the restoration project."* [15]

Also, in the actual debate about the relation between restoration and structures, the aspects related to the structure and to the architectural form must be taken in the single operation of the restoration, which is a "cultural operation" [16].

> *"The static intervention must provide the reinforcement work, but relatively to the historical existing buildings, and not with an uncritical and undifferentiated approach, but with according to the "values" to be maintained or recovered."* [17]

It is not necessary to explore the aspects related to the concept of authenticity, but it could be useful remind the most fundamental guidelines and principles of the restoration, which found their definition in already three hundred years of development, considerations and experimentations: the minimum interventions, the reversibility, the distinguishability, the chemical and physical compatibility, the expressive and not faked authenticity. All these criteria guide the restoration intervention focusing on an approach which respect the material and formal authenticity of the existing[18]. It is not correct also to deduce the preconceived disapproval of some materials and techniques, as the cement or the reinforced concrete[19], because in some cases the insertion of these elements constituted the possible solutions to the static problems. The faults are not related to the material themselves, neither to the techniques, but they regard the hand and the head of the people who use them excessively, the competence or incompetence of designers and workers. In general, the technological paradigm is never independent, and do not command the intervention, but, at the opposite, it must be guided by a historic-critical reason.

> *"It is not through nano-technologies or similar that the conceptual visions or the approach to the restoration will change. The techniques are and must remain instruments of the man to be used in an open and multidisciplinary way".* [20]

The structural overview on the analyzed restorations found the starting points in the same assertions, but trying to analyze also the consequences of reinforced concrete elements' impact on the existing structures. The application of reinforced concrete elements in the existing buildings provides the alteration of the static balance of the entire architectural organism. Up until the second half of the nineteenth-century buildings were built of masonry and their safety was entrusted to ''rules of thumb'', or—in the case of great works — to the experience of builders [21]. The problem of defining scientific models for masonry structures was not actually faced in Europe at least until the end of the World War II: this is motivated in one regard by the spreading of the new building techniques (steel and reinforced concrete) and in another by the acquired knowledge that masonry does not follow the laws of elasticity except for very limited loads. Poor knowledge of masonry structures, difficulty in interpreting their behavior through the tools of the science of engineering, and widespread mistrust in the empirical method through which ancient buildings were designed, produced interventions that tended to replace masonry structures with new resistant organisms, to ensure or ''cage'' masonry with rigid and reliable members in reinforced concrete [22]. In this way, all the structural observations about the applications of reinforced concrete in historical buildings can be referred not only to buildings located in seismic zones, as the central Italy and California, but also in other locations.

The mechanical aspect

The first evaluations from the analysis, related to the insertion of new elements, in substitutions or in addition to the existing building, involved the modifications of the structural behavior. With the example of Collemaggio (A_1|1, A_1|12, A_1|29), the alteration of the façade's composition, with the insertion of the hidden frame in reinforced concrete inside the walls, it had been clear how these applications modified the structural behavior during the seismic stresses' actions, involving torsional effects, which amplified the displacements of the interior columns of the basilica and the subsequent collapse of the transept. Also, the modification of covering systems in reinforced concrete, such as the domes, vaults and the new roof in reinforced concrete, involved modifications to the general static of the building, adding weight to the below structures.

Other aspects to be considered from the critical analysis are focused on the applications of top and bond beams in reinforced concrete on the masonry walls. Sometimes, with the insertion of this kind of elements, characterized by stiffness and quality of the materials completely different from the existing structure, some problems relative to the interaction of the materials and, also, of the structural element can occur. Another point to consider is related to the decay of the reinforced concrete quality which, after so many years from the applications can present some decaying phenomena, providing the reduction of its resistance characteristics.

Beyond the analyzed case studies, another reinforcement application of the concrete consisted in the injections of cement mortar inside the existing masonry. provided also the alterations of materials, involving chemical reactions, with also can provide the development of Delayed Ettringite Formation (DEF). The DEF phenomenon can represent a serious risk for the structural reliability and for the formal aspect, with the danger of expansion and subsequent cracking of concrete.

The development of the restoration approach and the structural comprehension in the last years increased largely, aiming to approach to the building only with global acknowledges, performing historical analysis, tests and simulations of models (both with macroelement behavior than to global model analysis).

The problems of reinforced concrete

The observed problems in this kind of applications involved the necessities of new directions of strategical interventions, aiming to solve them respecting the existing elements. The recent earthquake events, in particular from the event in Umbria-Marche 1997[23] and the latest quakes of L'Aquila 2009[24] and Central Italy 2016[25] showed the limits of the reinforced concrete applications, and in particular the mistakes in the local evaluation of the interventions, instead of the global comprehension of the mechanical behavior. Thanks to the researches performed in the last years, since Umbria 1997, which started a new phase of experimentations - after becoming aware of the inefficiency of the structural improvements of the previous restoration campaigns – to the present day, the intent of the structural comprehension and the improvement of the buildings' resistance took other directions, focusing also in the reinforcement of monumental buildings, aiming to guarantee their historical heritage.

> *"In this direction there have been made lot of developments, especially in the new generations of technicians who, even if they come from cultures and studies in which the reinforced concrete is the dominant culture, they started to study and deal with the specific problems of the masonry constructions and they understood how "heavy and strongly hybridizing interventions" let the loss of the authenticity of the building, upsetting the original*

> *concept. However, if the intervention had not been conducted in the right ways, interesting every structural element, some dangerous incongruences among the parts can occurred, with stiffness and resistances very different."* [26]

According to the identified insertion of reinforced concrete, the development of the technologies in the last years aimed to define the problem of the insertion in relation to the historical structures, evaluating the best strategical attempts to be pursued for the vulnerability's decrease.

> *The conservation of monuments does not reach defeats if with love, patience and method the interventions provide during times for the support of weak elements, the elimination of decaying processes, the help of the material when they are going to be old. The stability and its reinforcement must be the first therapy to reach by people aiming the preservation of the monument, instead of the reinstatements which impress the public."* [27]

All the performed analysis on the buildings [28], in particular on the buildings located in seismic zone, and which had been subjected to other earthquake after their interventions, showed the inefficiency of the structural constraints between bond beams and masonry walls, also in the case of top elements supporting the roof systems. The seismic events demonstrated how these systems have not been able to transmit the actions to the lower elements, because of the lack of structural continuity [29]; in this way, letting the overturning behavior of the walls, instead of shear cracks.

The debate about the insertion of top beams, which involved damages to the historic structures during the times, referring in particular in seismic zones with the happening of new quake events, must be analyzed with particular attentions. Also with the newest rules of constructions [30], reinforced concrete beams are allowed, taking some shrewdness, as the low thick of the elements and the links to the below masonries [31].

Due to this lack of linking systems, one of the possible attempts, in the case of top beams in reinforced concrete, could be found in the necessity of insertion of linking vertical elements between the beams and the masonry walls. In this way, an important foreword is represented by the necessary acknowledge about the characteristics of the masonry, which primary induced the behavior of the building according to the relation to the other elements. In this case, the insertion of columns and beams in reinforced concrete, without any reinforcement of the masonries, can involve the collapse of the building, as already happened in historic buildings[32] after the recent quake events. The quality of the vertical masonries has a primary role in the structural behavior of the building. It must be sufficient in comparison to the new vertical loads from the reinforced concrete upper additions, and, especially, from the shear stresses increased by the interventions. In this case, masonry must have physical and geometrical characteristics able to reach the behavior as a "structural and bearing material".

According this point, the new campaigns of restoration are inducing a different approach to the structures[33]. Leaving the "old" techniques of reinforcement, which modify the masonry building in reinforced concrete frames with curtain walls in masonry, or inserting the so-called "anti-seismic" roof or slab, the approach of nowadays point to lightweight solutions.

The typology and the methods of realization of the interventions are also indicated in the *General Instructions for the Restoration Projects in the Architectural Buildings of Historical and Artistical Interest in Seismic Zone* [34] , updated in the *Guidelines for the evaluation and the reduction of the seismic risk ion cultural built heritage*[35]. The last updates of the rules about the preservation off historic buildings in seismic zone, according to the *Code of Cultural Heritage*[36] , maintained the same target, which must to be reached combining the different necessities of safe and preservation, aiming to pursue a restoration interventions which provides also safe conditions for the building. With the intent of collaborations and synthesis among the aspects relatively to the structures and forms, the managing of reinforced concrete elements in the restored buildings also today represent a point of debate about the maintenance or the removal. In particular, the problem of nowadays can be also evaluated according to the point of view of the historicization of the interventions which, even if some of them still today represented virtuous example, can be considered a problem for the transmission to the futures, according their structural impact on the buildings.

Starting from the definition of "restoration" contained in the Code of Cultural Heritage[37], the "improvement" has also become an integral part of the restoration as a rule; this aspect must be read in two directions. In the first corollary, restoration cannot fail to include, taking responsibility for it, the works necessary for the structural repairs and preventive conservation of the properties in the face of future seismic events; according the second direction, the improvement must make all possible efforts to reduce its impact on the factory and seek the compatibility of the interventions with its architectural and material characteristics[38] .

Restoration and RC today

Today, the use of reinforced concrete, in all the analyzed contexts, continues to be pursued, with more attentions and specifications in comparison to the "miraculous material" of the first half of the century, which provided solutions for all the restoration and reinforcement interventions. There are not best materials in comparison to the others, but only good design against bad [39]. However, the existing structures, cause of also their age, now can be analyzed as historic part of the buildings, and so, treated as historical elements. The necessary analysis of the global and local behavior of the elements must be performed aiming to the necessity interventions, trying to maintain the original elements and forms, and showing the eventual additions or modifications.

In conclusions, it could be useful also to analyze one of the last restoration intervention which interested a restored building hit by recent earthquake, such as the Basilica of Santa Maria di Collemaggio, whose restoration intervention had been concluded in December 2017. In particular, with the state of the damages involved by the earthquake of April 6th 2009, the basilica suffered the lack of resistance of the two main pillars of the transept, which, with the displacements inducted by torsional effects of the façade, together with the heavy structure of the upper dome, collapsed completely, involving the collapse of the entire transept. The realized interventions interested the use of reinforced concrete elements; in particular, the two main columns of the transept areas have been realized in reinforced concrete, while the other existing pillars have been reinforced with steel bars. The upper part of the basilica has been reinforced with the insertion/reinforcement of top beams the new realized in reinforced masonry, while the other – probably – had been reinforced. Instead of the recovered elements, the dome has not been reconstructed, with the visibility of the timber trusses, aiming to "guarantee the visual continuity"[40].

"The periodic inspection and the scheduled maintenance of the objects constituting the cultural heritage are surely the methods on which the preservation politics must be based." [41]

Fig. 6.1
The foundation of the new pillar in reinforced concrete of the reconstructed area.

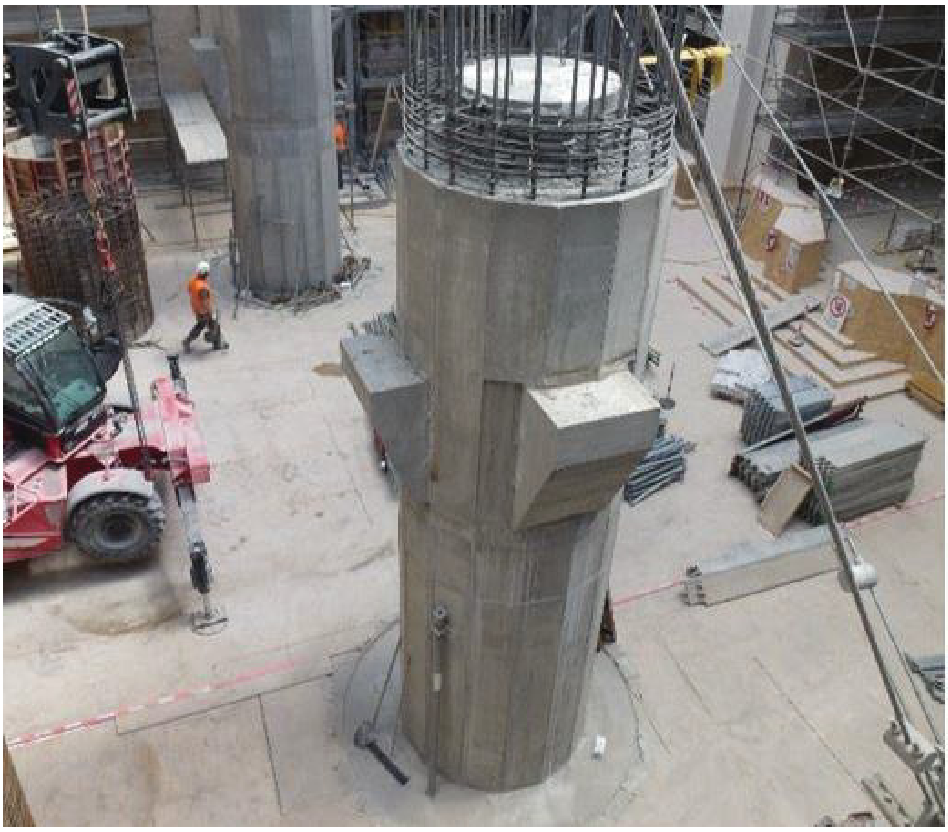


Fig. 6.2
The new pillar in reinforced concrete, realized in the reconstructed area.

Fig. 6.3
Interior of Collemaggio today. The differences of materials between the original walls of the nave (left) and transept (right.

Giorgio Torraca, a distinguished academic working in the safeguard of cultural heritage, expressed his contribution about the restoration theory, aiming to define the correct approach of the interventions.

> *"From a purely conservative point of view, the restoration of a work of art which does not aim to the holding in group the pieces avoiding the risk can be*

considered dangerous. […] The restoration is a philological operation of taste and image recovery which is strictly connected to the function of guide values of the human society: it is so necessary. But it is also clear that the restoration must be limited to the cases in which the historic technicians assert its necessity […] while a large number of works must be conserved with the maximum respect of the informative subject (the aesthetic, historical and scientific aspect), applying rigidly the minimum intervention principle and acting aiming to modify the context conditions, as the exchange with the environment." [42]

notes

[1] The last laws, Norme Tecniche per le Costruzioni, avoid the use of reinforced concrete top beams above the masonry walls (NTC 2018).

[2] Phase 0, Phase 1 and 2, including the restoration of the Loggia di Papi in Viterbo which can be analyzed as well.

[3] As for example the case of the Basilica of San Clemente in Castiglione a Casauria.

[4] Negatively because of the direction which took lot of the interested restoration interventions.

[5] Giovannoni, 1929.

[6] Ibidem.

[7] Giovannoni, 1945.

[8] The restoration pursued on the Alamo reflected the points of the Athens' Charter, in which the restoration in anastylosis is admitted only if the new elements are different from the existing ones, while the Californian restoration had been pursued mostly in the Thirties, but following the Giovannoni's theory aiming to hide the structural new elements. The case of the dome in San José is emblematic.

[9] Cf. Chapter 1. Introduction.

[10] Also confirmed in the evaluation of the restoration project of San Pietro in Albe.

[11] Brandi, 1963.

[12] And so the famous definition of the restoration: *"The restoration constitutes the methodological moment of the identification of the work of art, in its physic consistence and in the double aesthetic and historic polarity, in view of its transmission to the future"*.

[13] Brandi, 1963.

[14] Ibidem.

[15] Carbonara, 1997.

[16] Boscarino, 1984

[17] Carbonara, 1997.

[18] Carbonara, 2017.

[19] Carbonara, 1981.

[20] Carbonara, 2017.

[21]The new science of engineers, codified between 1820 and 1830, led to the definition of a new conception of safety, based on scientific models and quantifiable parameters. This conception was strongly linked with those materials that, starting from the beginning of the nineteenth century, began to be produced on an industrial scale (Benvenuto, 1991).

[22] Calderini, 2008.

[23] Cf. chapter 1_1 in the section and note no. 20 about the earthquake of Umbria and Marche of 1997. Cf. also note no. 35 of the previous chapter.

[24] Augenti et al., 2010; D'Alberto, 2011. Cf. also note no. 36 of the previous chapter.

[25] In 2016 central Italy suffered two different strong earthquakes. The first event occurred on August 24th and had epicenter in the city of Accumuli, in the area near the borders of Umbria, Lazio, Abruzzo and Marche regions. 6.2 degree in Richter scale, the event made the destructions of the city of Amatrice and spread damages in the neighborhood and it caused 299 deaths. The second main event occurred in October 30th and it had been one of the strongest earthquake in the Italia history, with a magnitude of 6.6 degree in Richter scale (the main event had been preceded by two foreshocks of 5.5 and 6.1 degree in the days before. This last event caused the destructions of some historical buildings, among them also the Basilica of San Benedetto in Norcia.

[26] Borri et al, 2010, 2017.

[27] Giovannoni, 1929.

[28] Including also other buildings which have not been analyzed in the dissertation.

[29] Lot of times, the top and bond beams are simply placed on the walls, without any connection elements, such as steel bars [30] Norme tecniche per le costruzioni, 2018.

[31] Lagomarsino, 2009.

[32] Also ordinary buildings, not only monumental.

[33] Which is also reported in the new building codes, as the NTC 2008 and the more recent NTC 2018.

[34] *Istruzioni generali per la redazione dei progetti di restauro nei beni architettonici di valore storico-artistico in zona sismica*, established by the Comitato Nazionale per la Prevenzione del Patrimonio Culturale dal Rischio Sismico del Ministero per i Beni e le Attività Culturali, 2002.

[35] Linee guida per la valutazione e la riduzione del rischio sismico del patrimonio culturale con riferimento alle Norme tecniche per le costruzioni di cui al decreto del Ministero delle Infrastrutture e dei trasporti del 14 gennaio 2008.

[36] Codice dei Beni Culturali, 2004.

[37] Ibidem.

[38] Reggiani et al., 2011

[39] Of course all the pursuable structural approaches to the restoration structural insertions, even reinforced concrete than steel or timber, must be designed according to the correct methods and ways.

[40] Vittorini, Il Giornale dell'Arte, online magazine.

[41] Torraca, 1983.

[42] Ibidem.

CONCLUSIONS

Additional researches

This dissertation constitutes can be also considered as a starting point for additional researches, which can be applied in the lot of field correlated to the history of architecture and to the restoration and preservation.

In particular, the analysis of case studies, focusing the central part of Italy and the southern part of United States, gave the opportunity to understand how, from the late Ten to the Thirty years, the role of reinforced concrete started to be primary in all the works related to the building field.

The Thirty Years worldwide

The analysis of the interested case studies gave the possibility to understand and remark that, in the first part of the analyzed period, reinforced concrete started to be considered as an important and primary material in all the construction fields. It could be interesting analyze all the factors which, from the first patents at the end of 19th century, involved reinforced concrete to be so spread globally in the period from the late Ten to the Thirty years, arriving in 1931 to the Athens' Charter declarations as an instrument already approved by the numerous experiences pursued, also in the restoration fields. The analysis of other case studies relative to this period can be important in this kind of evaluations, as also the study of northern interventions and factory developments, regarding the reception of Hennebique system's patent, with the use of frames of reinforced concrete as structural solutions. This could be performed also with the study of the engineers or companies which, coming from the northern part of Italy, came in the central area pursuing some of the analyzed restoration works [43]. Also, other aspects that can be analyzed are related to the movement of technicians from the context of the other major earthquake which characterized the first years of the 20th century, as the earthquake of Messina-Reggio. In parallel, it is remarkable to inspect and examine the relations among the technicians and the companies of the different areas of study, in particular Texas/California (United States in general) with the

Italian and European experiences, always focusing on the period above-mentioned.

Deepened structural evaluations

As the Collemaggio's example, other analysis performing in the other selected case studies can be important for general evaluations about the impact of the inserted structures in reinforced concrete in the original masonry buildings. The study of the structural impact of this kind of restorations could be primary in the evaluations for the buildings vulnerability and also to the individuation of strategic lines of interventions. Keeping in mind that every building presents specific aspects and characteristics, this possibility aims not to define general rules to be meticulously followed, but it intends to explain possible directions of interventions, applied according to the typology of buildings and restoration in reinforced concrete. Of course, every evaluation about the intervention must be expressed with the necessary acknowledge about the existing building, with the analysis of data, historical research, surveys and tests [44].

"The actuality of reinforced concrete could consist today in its restoration, rather in its anti-restoration" [45]

"Reinforced concrete material"

With the sentence by Jacques Gubler, another point of interest in the additional research is represented by the study of the "reinforced concrete material". The decay of the reinforced concrete, due to its crumbling, corrosion of steel bars, opens necessary to new scenarios in the future interventions. Keeping in mind that the interventions, large part of which had been realized more than fifty years ago, present reinforced concrete elements which, probably according to the realization of the materials in that period, have already started their decrease. Since the development of the material, the decay phenomena was commonly renown, and the first attempts in the decay mitigation started few years after the first patents, in the Twenty years of the 20th century [46]. Theorists tried to solve the problem since the Thirty years [47], increasing the debate in the second post-war. However, in this last period the use of reinforced concrete spread all over the world, with the different typologies of insertions [48]. All these evaluations can be important for the structural behavior of the buildings in case of new seismic stresses. In particular, due to the structural decay, reinforced concrete elements could have lost their resistance capacity, letting the building more vulnerable as it was after the interventions. Also, the reinforced concrete elements can have problems related to the chemical reaction with the existing mortar inside the masonry: the phenomenon of ettrinx, which involved the reaction of the cement and calcium and make the ettrinx with increase of volumes, can generate cracks and fissures to the reinforced concrete elements, showing unpleasant and unsafe aspects to the view and, especially, can facilitate also phenomena of decay of the steel bars due to corrosions. In this way, specific analysis on the state of the structures could be relevant and important for the correct evaluations and the necessary strategies of recovering interventions. [49]

Modern architecture

All the explained hypothesis of future developments of the research can be considered also in another field of the history of architecture, in which reinforced concrete became a fundamental element of definition and not only structures. According to the conducted study and also to the first part of this paragraph, the study of their development and the use of reinforced concrete as the structural and formal material, can find lot of common aspects with the restoration applications of the modern material, being applied in comparable periods and with lot of the same characters which influenced the worldwide debate about the use of new materials in architecture.

Also, the analysis of the behavior of modern architecture buildings can be related to the necessities, also in this case, of evaluation of some guidelines of interventions. Differently from the restorations, the structural analysis of historical buildings in reinforced concrete, due to the rules of the new materials and the logic of the structures, can provide general guidelines, which can be applied indifferently to all the specific kind of buildings.

The modern architecture, which, as the interested interventions of restorations, present – more or less- the same time of the interventions, can be suffered the same problems relative to the decay of the reinforced concrete structures, and be subjected to phenomena of capacity decrease.

notes

[43] In both the cases there are families of engineers, as Inverardi, or other technicians which started operating in the northern areas of Italy and, after changing their work position, came in the central part of Italy and established their activities, continued in the restoration works of the interested periods. Another example, which could be interested to discover, can be related to the figure of the engineer Paolo Cassinis, who, coming from Turin, established firstly in Avezzano (AQ), then in Sora (FR), working in the reconstruction projects after the earthquake of Marsica 1915. The same approach can be done also for some companies which started to work in the area hit by the earthquake.

[44] In this case the typologies of approach can be different. Analyzing only the Abruzzo's area, Donatelli for example (2010) provided an approach method related to the analysis of historical architectures damaged by earthquake events. Choosing buildings which were not interested by renovations or additions during times (taking as references rural churches usually in state of abandonment after the quake events), the analysis had been performed aiming to define general evaluations applicable to the local cases. A similar approach can be done for buildings of the comparable areas/periods, which presented alike typologies of interventions, aiming to identify general behavior and, consequently, general directions of improving interventions.

[45] Gubler, 1992

[46] The structural resistance, the monolithic behavior of the elements, the trustable and versatility were assumed "eternal" in the first assertions about the possibilities of use (Di Biase, 2015).

[47] The problems related to the "historical concrete" which interest large part of the analyzed restorations, started to be analyzed, with the solution proposals consisting in the insertion, inside the existing elements in reinforced concrete, of cement injections, avoiding the cut of the steel bars.

[48] Already seen in the analyzed areas according to the different rules.

[49] Also the protection intervention on concrete's surfaces can alter and modify the aspect and the form of the original elements, being also invasive. As for example, one of the most urgent solution regard the corrosion problem, in which the development of electro-chemical technologies reaches interesting results (Di Biase, 2015).

Appendix

DATABASE OF THE ANALYZED INTERVENTIONS

Summary tables of the interventions

Analyzed Restorations in Central Italy

Summary tables of the Interventions among Abruzzo, Marche, Umbria and Lazio

A_1 Case studies in Abruzzo

A_2 Case studies in Marche

A_3 Case studies in Umbria

A_4 Case studies in Lazio

Analyzed Restorations in United States

Summary tables of the interventions among Texas and California

B_1 Case studies in Texas

B_2 Case studies in California

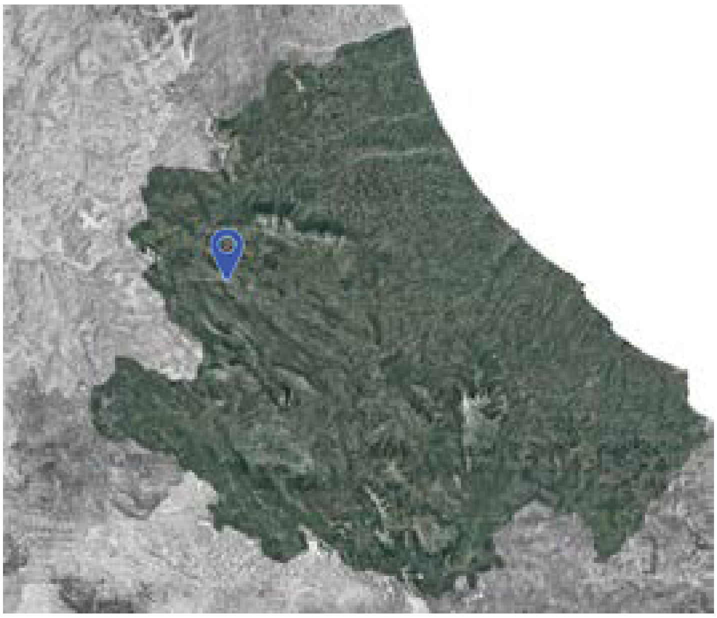
Church of Santa Lucia in Magliano De' Marsi in 1902 (ICCD)

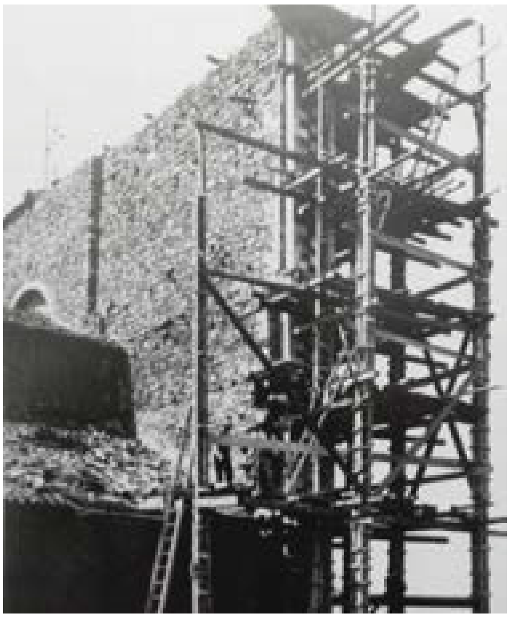
BASILICA OF SANTA MARIA DI COLLEMAGGIO

L'Aquila | first intervention

Description

The basilica of Collemaggio had been founded in 1287 and it rapresents one of the most important building of the city of L'Aquila. After many changes, which modified the architecture and removing the baroque decorations, the church today shows its romanic aspect. The facade, realized in the second half of the 14th century with precious geometrical weave, present three gates, decorated with arches and columns, with recesses inside which there are positioned small statues. The interior of the building is divided in three different naves, which intersect the transpet. The final apse closes the architecture. The basilica, since its foundation, had been interested by the earthquakes, which involved the modification of the structural elements. In particular, the event of 1915 involved the two analyzed restoration interventions.





Code: A_1 | 1

Analyzed Restoration Intervention

Period of restoration	**1919-1921**
Client	**Soprintendenza ai Monumenti e Gallerie dell'Aquila** **Soprintendente A. Munoz**
Designer	**I.C. Gavini | R. Biolchi**
Company	**A. Di Francesco**

The first restoration intervention on the Basilica provided the reinforcement of the main facade, with the insertion of a frame in reinforced concrete. In particular, the structure aimed to give the necessary stiffness, avoidign the elevate displacements of the upper part, which involved the presented damages with the earthquake of 1915. The frame had been composed of two lateral columns, in correspondence of the longitudinal walls, and two different beams, which one had been positioned to the top of the facade. The works started with the deassemblation and cataloguing of the covering elements of the facade, which after the realization of the structure had been repositioned.

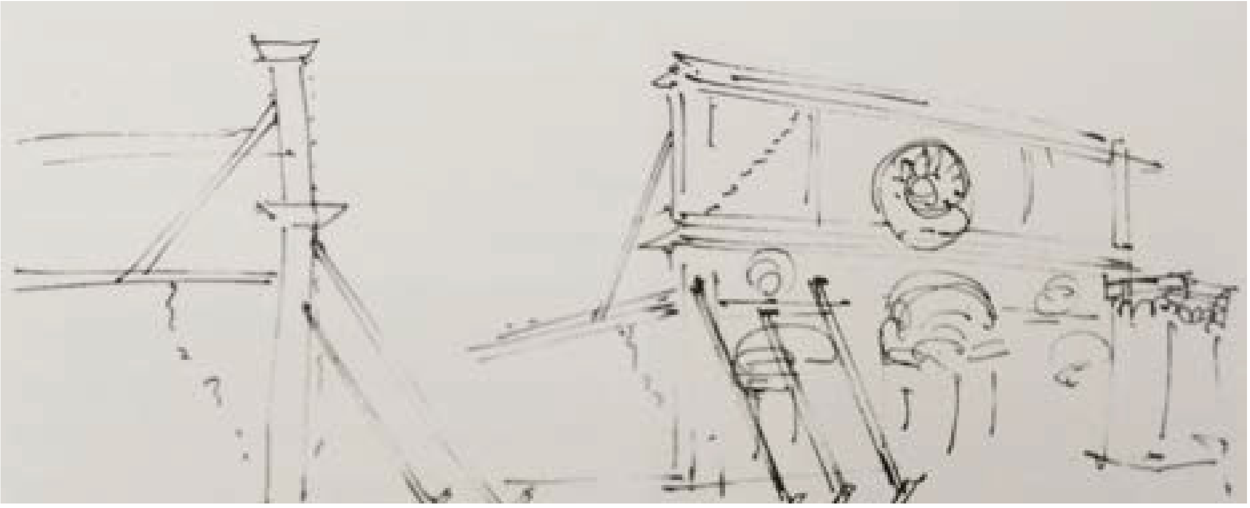


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *(2017) - Collemaggio*
- *Abbate (1903)*
- *Antonacci, Beolchini et al. (2001)*
- *Antonacci et al. (2010, 2012, 2013)*
- *Antonini (1988)*
- *Bartolomucci (2004)*
- *Carbonara (1995)*
- *Chierici (1945)*
- *De Angelis (1903)*
- *Gavini (1915, 1921, 1923, 1927)*
- *Gizzi (1988)*
- *Marchetti (2009)*
- *Miarelli Mariani (1979)*
- *Moretti (1972 a, b, c, d)*
- *Pezzi (2005)*

BASILICA OF SAN CLEMENTE

Castiglione a Casauria (PE)

Description

The abbey of San Clemente had been built in its first core in the 9th century. After different phase of constructions and raids, the church became re-consecrated in the second half of the 12th century. Interested by earthquakes during its life, the architecture had been modified different times. The facade is preceded by a portico with three fornixes, called also esonartex, with the main gate with round arch and the laterals with pointed arches. The interior is divided in two different areas with a mid triumphal arch; the three naves are different size, ending in the final apse. Precious decorative elements, as the cyborium and the ambon characterize the interior of the space.

Code: A_1 | 2

Analyzed Restoration Intervention

Period of restoration	**1919-1923**
Client	**Soprintendenza all'Arte Medioevale e Moderna di Abruzzi e Molise Soprintendente A. Munoz**
Designer	**I.C. Gavini**
Company	**/**

The solution proposed by Gavini aimed to maintanin the preexisting heights of the main nave and removing the additions with the sacristies. With the liberation of the transept, the large rectangular room loses one side of its perimeter, with the separation of the presbytery and the liturgical spaces. Not being able to reconstruct the triumphal arch, Gavini decided to insert a new linking element, able to resist to traction and compression stresses: a beam in reinforced concrete. The same method had been applied in correspondence of the transept. The drastic choise of this use can be justified in the intention of recreate a wanted disharmony, far from the creation of an aesthetic perfect system, but only functional.

Table of restoration's cataloguing

PHASE 0	**Earthquake**	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Bartolini Salimbeni (1993)*
- *Biolchi (1932)*
- *Bollettino d'Arte, IV, April 1926*
- *Carbonara (1995)*
- *Colangelo (2004)*
- *Felli (2019)*
- *Gavini (1923, 1924, 1926, 1927)*
- *Giovannoni (1923)*
- *Parente (1912)*
- *Varrasso (1993)*

CHURCH OF THE SAINTS GIOVANNI BATTISTA E EVANGELISTA

Celano (AQ)

Description

The church, founded in the 13th century but completed nly two centuries later, presents a simple facade, linear and gable roof. The only one gate present on the facade is standed above by the rose window, which is characterized by precious decorations. While the gate is only one, the interior is divided in three different naves with octagonal columns and pointed arches of the 13th century, while the valuts had been reconstructed after the earthquake of 1915, which involved serious damages. On the right nave, there are still today some particular and precious frescoes.

Code: A_1 | 3

Analyzed Restoration Intervention

Period of restoration	**1931**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise Soprintendente A. Munoz**
Designer	**I.C. Gavini**
Company	/

Seriously damaged by the earthquake of 1915, the restoration work had been directed by Gavini; the cross vaults had been reconstructed, while the rest of the intervention interests the baroque ddecorations, which had been removed, showing the precious frescoes. While the dome and the lantern were not reconstructed, th last three spam were rebuilt with also some pilasters (maybe never existed). The entire roof structure had been realized in reinforced concrete structure with hollow brick elements.

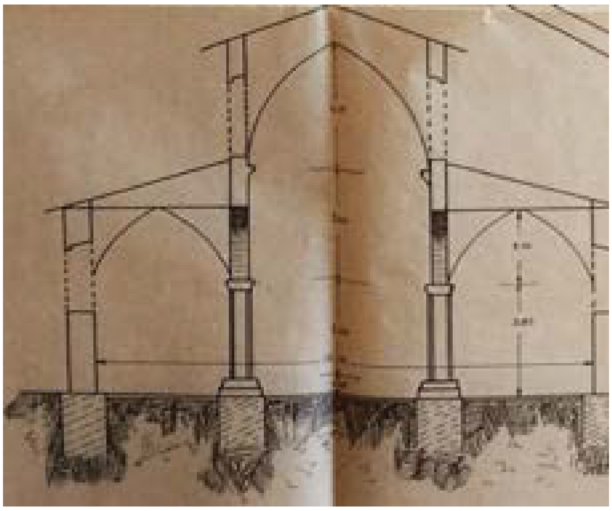


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

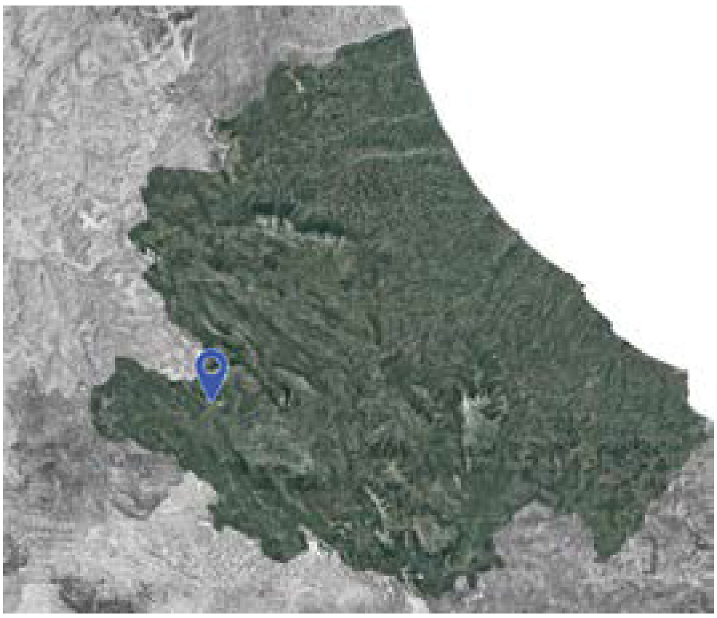
- *Abbate (1903)*
- *Bartolini Salimbeni (1993)*
- *Bollettino d'Arte, II (1915)*
- *Carbonara (1995)*
- *Ciranna et al. (2015)*
- *Donatelli (2012)*
- *Mancini (1996, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *ASGCRegAz*

CHURCH OF SANTA LUCIA

Magliano De' Marsi (AQ)

Description

The church, built in the 13th century, suffered several damages with the earthquake of 1915. The facade, which had completelly deassembled and repositioned after the works, presents three different gates with pointed arches; the upper level of the front is characterized by the presence of a rose window and, above it, a window with lateral pilasters, and other decorations. The interior is divided in three naves; the internal architecture is the result of the restoration project, which after the earthquake, aimed to recreate the original structures, avoiding the reinstatement of the baroque decorations.

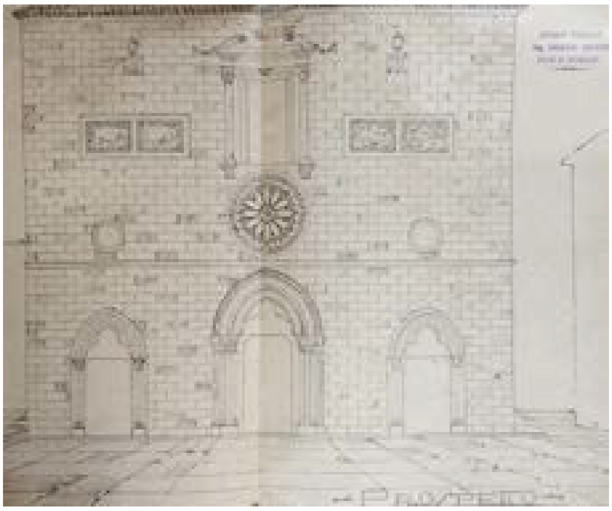


Code: A_1 | 4

Analyzed Restoration Intervention

Period of restoration	**1934-1937**
Client	**Soprintendenza Monumenti e Gallerie dell'Aquila** **Soprintendente A. Riccoboni**
Designer	**C. Sabatini | F. Pietrangeli**
Company	

The engineers Sabatini, firstly, and Pietrangeli, secondly, designed the restoration project, which took the period from 1928 to 1937. The project provided the insertion of a new structure in frame of reinforced concrete inside the walls, the rebuilding the collapsed walls in bricks; particular solution had been pursued in the new roof, with the creation of trusses in reinforced concrete, hidden by wood boards, able also to link the entire system to the main façade, which had been disassembled, reinforced and reassembled with the original elements, previous catalogued. The foundation level had been improved with the insertion of foundation beams and, in correspondence of the central columns, plinths.



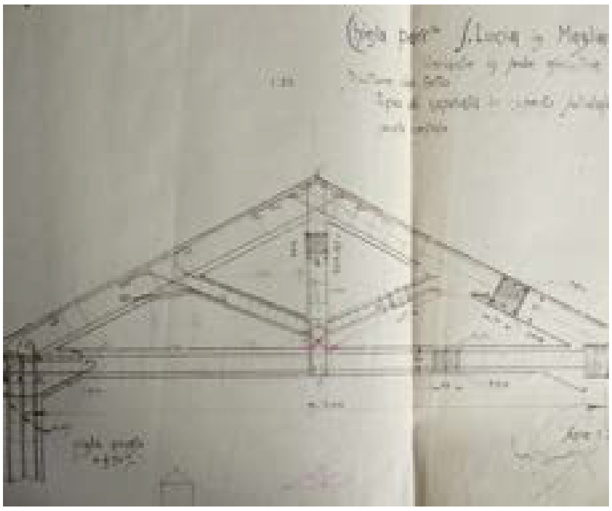


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

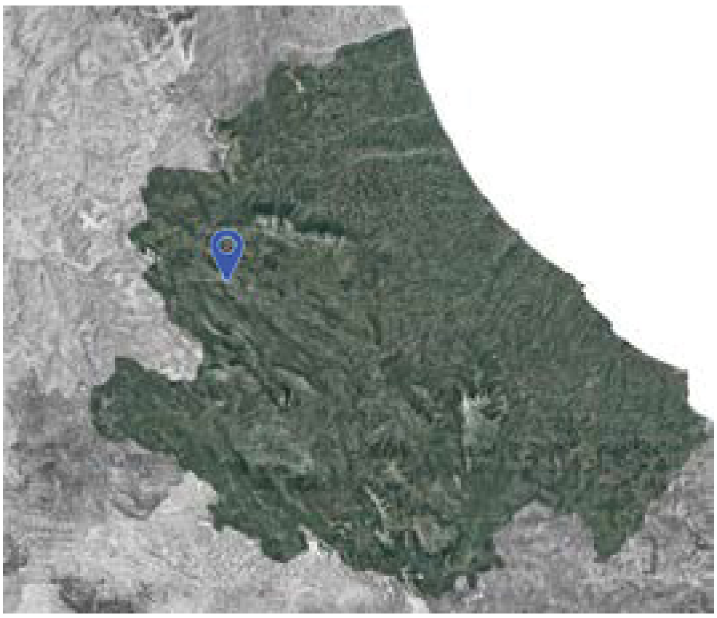
- *Abbate (1903)*
- *Barbato et al. (1978)*
- *Ciranna et al. (2015)*
- *Di Cristofano et al. (2015)*
- *Donatelli (2012)*
- *Gavini (1927)*
- *Mancini (2004)*
- *R. Soprintendenza (1915)*
- *ICCD, Gabinetto Fotografico*
- *ASGCRegAz*
- *ASC.Magliano*

TOWER OF THE MUNICIPALITY

L'Aquila

Description

The tower of the municipality had been nterested several times by earthquake, which modified the aspect and also the heigt of the building (originaly 70m height, during times the tower had been lowered). The tower shows four different levels with sculptured cornices, in the last of which there is the clock tower and, and the top, the bell lantern. The tower suffered damages with the recent earthquake of 2009. which involved damages cause of the hammering behaviour with the close palace of the municipality.



Code: A_1 | 5

Analyzed Restoration Intervention

Period of restoration	**1937**
Client	**Provincia dell'Aquila**
Designer	**A. Riccoboni**
Company	**Ettore Barattelli, L'Aquila**

The restoration project, designed by Riccoboni, aimed to give back to the tower its original aspect; initially studied for reaching the original 70 meters of hight, the project had been modified, trying also to reopen the four arches of the top level, the renovation of the merlons and the recollocation of the emblems to their original position. The reinforcement works provided the realization of binding steel ties in proximity of the string courses, with also ties in reinforced concrete in correspondence of the top brackets, fixing also the other fissures.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams't insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

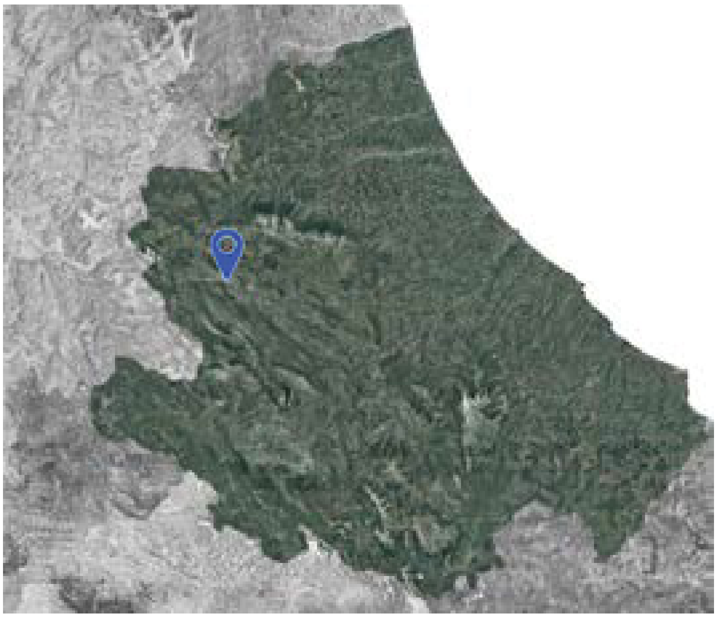
- *Capezzali (2011)*
- *Centofanti (1979, 1992)*
- *Clementi et al. (1986)*
- *Lopez (1988)*
- *Marchetti (2011, 2013)*
- *Reggiani (2011)*
- *Sconci (1983)*
- *Stockel (1981)*
- *AS.BAR*

BETTI PALACE

L'Aquila

Description

The palace had been built after the Unification of Italy, in the second half of the 19th century, according to the will of the lawyer. Used also as the proscenium of Mussolini's speech , in the Thirty years of the 20th century the building suffered some modifications, in which there were inserted the other entrances on the lateral sides. In the second post war, the building became property of the Banco di Roma. Situated in front of the main square of the city, the building presents a square plane with an internal courtyard; the main facade, realized in neo-Renaissance style, is organized according to the palace typology, with three levels, the mid of which is the piano nobile, and three orders of five windows. The vaults of the piano nobile present interesting frescoes.



Code: A_1 | 6

Analyzed Restoration Intervention

Period of restoration	**1950s**
Client	**Banco di Roma**
Designer	/
Company	/

According to the necessities of the Banco di Roma, the building, becoming also one of the headquarters of the bank, needed to modify the interior distribution. The insertion of new structures in reinforced concrete, in a way to realize the spaces for the vertical connections and the bank vault (in this last case also with the insertion of bearing walls in reinforced concrete). With the earthquake of 2009, these modifications, involving torsional behaviour inside the building, comported several damages to the entire palace.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Centofanti et al. (2011)*
- *Colapietra et al. (1997)*
- *Moretti et al. (1974)*

PICCOLOMINI CASTLE

Celano (AQ)

Description

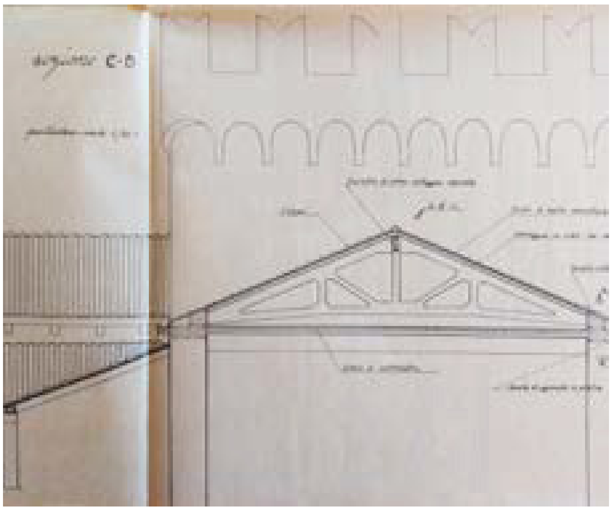
The Piccolomini Castle had ben founded among the 14th and the 15th century, being realized according to the Abruzzo's Gothic and Renaissance styles. Square plane, the building has four different towers at the corners, with a perimetral patrol communication trench with merlons. A large arched door, inside which a low Angevin arch is inscribed, and which was once accessed by means of a drawbridge, gives access to a large entrance hall to the courtyard, with a double order of arches; the acute lower ones, the round upper ones, supported by travertine columns, with fat Gothic capitals. In the middle, two columns which once supported an architrave.

Code: A_1 | 7

Analyzed Restoration Intervention

Period of restoration	**1940-1955**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise** **Soprintendente R. Delogu**
Designer	**Ufficio Tecnico del Genio Civile | R. Martegiani, D. Drisaldi**
Company	**Cingoli, Teramo**

The restoration of the castle attempted to reconstruct collapsed parts of the building, as well as the reconstruction of slabs and roofing systems. The works began and stopped in 1940, were reclaimed in the period from 1950 to May 1956. The main interventions concerned the introduction of new slabs, thanks to reinforced concrete systems, perimetral top and central beams with a roofing system in reinforced concrete and hollow tiles - mixed with reinforced concrete beams or trusses.



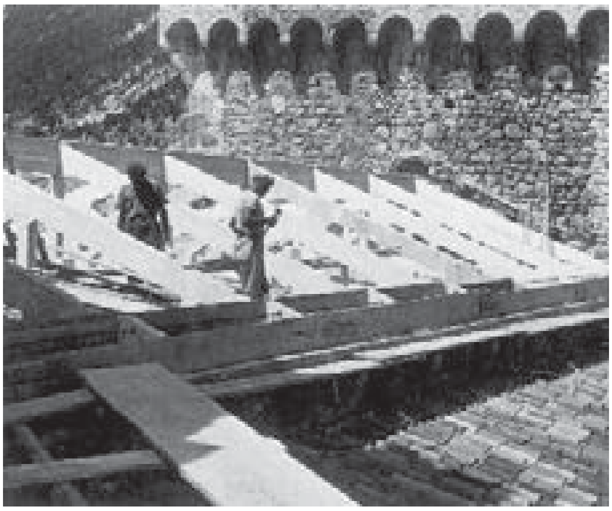


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

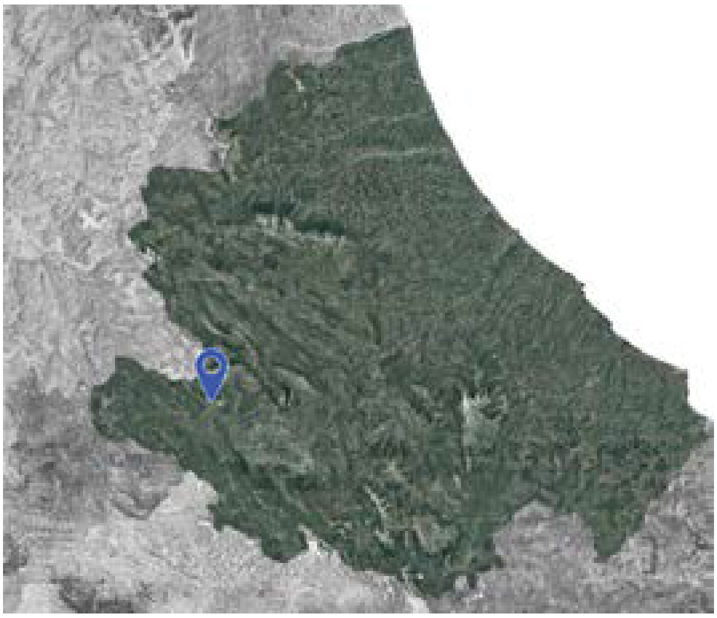
- *Abbate (1903)*
- *Barbati (1893)*
- *Carbonara (1981)*
- *Corsignani (1738)*
- *Gavini (1927)*
- *Mancini (2004)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *R. Soprintendenza (1915)*
- *Soprintendenza (2000)*
- *ASGCReg.Az*

CHURCH OF SANTA MARIA IN VALLE PORCLANETA

Rosciolo (Magliano De' Marsi Municipality | AQ)

Description

The church of Santa Maria in Val Porclaneta is one of the most interesting examples of Abruzzo Romanesque art. The gabled facade is preceded by a covered atrium (exonartex) with a single round arch and a gable roof. The church has a basilical plan, divided into three naves by massive square pillars and ending with a semicircular apse; three stairs lead into the presbytery, raised due to the rectangular crypt that develops in the space below. Of great artistic value are the ambon, the ciborium and the iconostasis. The iconostasis is composed of two stone slabs, probably made by different artists, surmounted by four columns that support a wooden architrave.

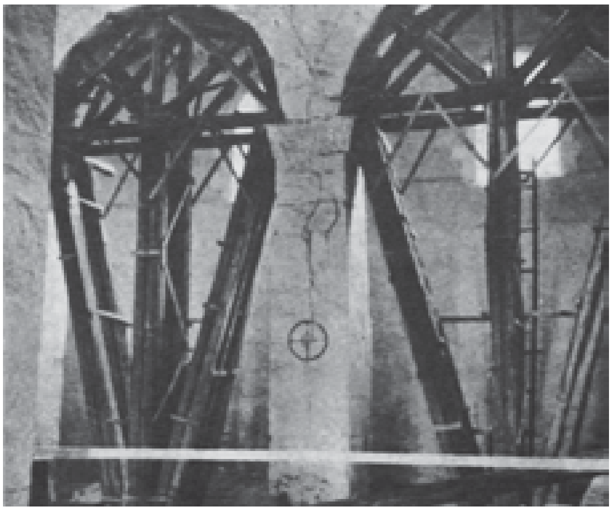


Code: A_1 | 8

Analyzed Restoration Intervention

Period of restoration	**1942-1955**
Client	**Soprintendenza all'Are Medievale e Moderna per l'Abruzzo e il Molise**
Designer	**Soprintendente U. Chierici | Ufficio del Genio Civile**
Company	**Arioli, Ortucchio**

The restoration work, which began in 1942 and resumed in several stages due to the advent of the Second World War, involved the reopening of the buffered arches, by reinforcing the wall and pillars; the first one had been reinforced with cement-based injections, while the second had been dismantled, consolidated with injections and reassembled, the others dismantled instead, replaced with concrete pillars, and finally reassembled. The foundation plan has been completely rebuilt, in order to ensure homogeneity of the structure in the support on the ground. The roof is redone in wood, using a new reinforced concrete top beam system in order to limit seismic actions.



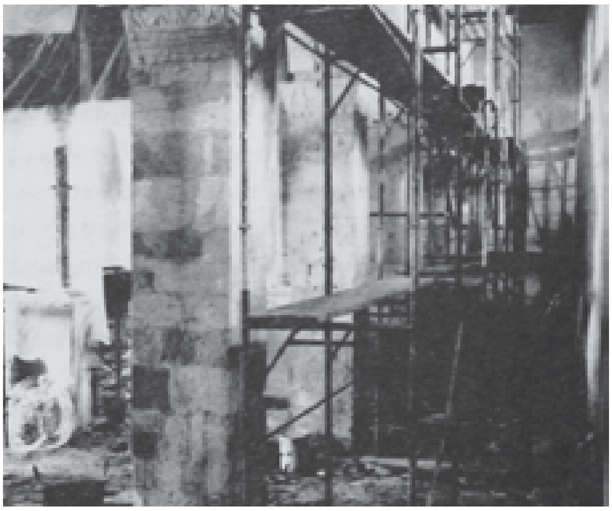


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

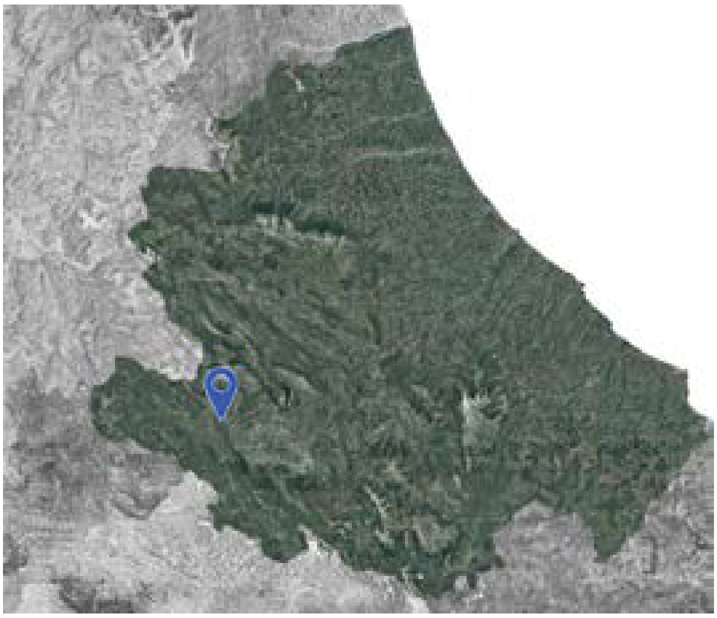
- *Abbate (1903)*
- *Angeloni (2000)*
- *Bertaux (1904)*
- *Bindi (1889)*
- *Cafiero (1968)*
- *Chierici (1945 b)*
- *Piccirilli (1889)*
- *Romeo (1967)*
- *Trizio (2008, 2017)*
- *ASC.Magliano*
- *ASGCReg.Az*

CHURCH OF SAN PIETRO IN ALBE

Alba Fucens (Massa D'Albe Municipality | AQ)

Description

The church of S. Pietro in Albe represents one of the most important monuments in the region for its architecture and decorative furnishings. The church is located inside the archaeological area of Alba Fucens and was built in its present form in the 12th century by the Benedictines, on the perimeter of the ancient Italic temple dedicated to Apollo (3rd century BC). Over the centuries the church has undergone various modifications and adaptations that occurred following changes of ownership and disastrous earthquakes (1465 and 1703), the last of which, the terrible earthquake of 1915, heavily damaged the structures and the beautiful furnishings presbytery. The interior presents three naves, a raised presbytery on a small crypt and a semicircular apse.



Code: A_1 | 9

Analyzed Restoration Intervention

Period of restoration	**1955-1957**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo**
Designer	**R. Delogu, A. Angelini, F. Panella, S. Ferri**
Company	**Augusto Stinellis**

The project provided for the insertion of a continuous frame in reinforced concrete in the entire structure of the church, comprending also the roof system and the foundations, creating a "cage" able to resist to quake stresses. The executive phase of the restoration site started with the deassemblation also of the floor, whose elements had been numbered and catalogued, for reinforcing the foundation level and creating the plinth of each concrete column. In the upper part, the reinforcement of the columns had been linked also with the beams in reinforced concrete, making the upper part of the frames. Also, the top beam of the tower bell and of the aisle were realized at the same height, in a way to connect all the elements.

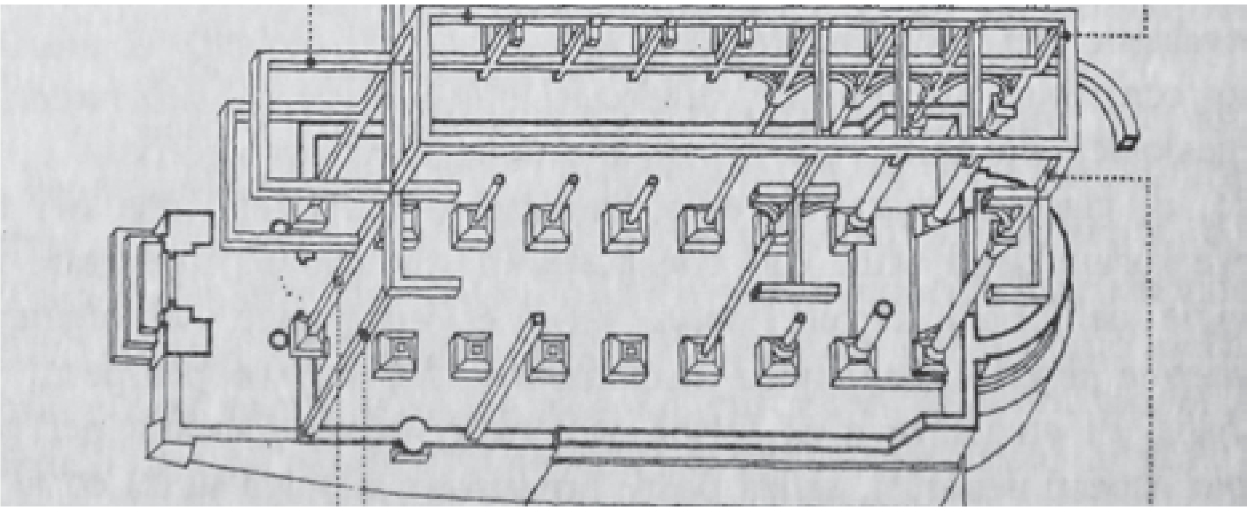


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

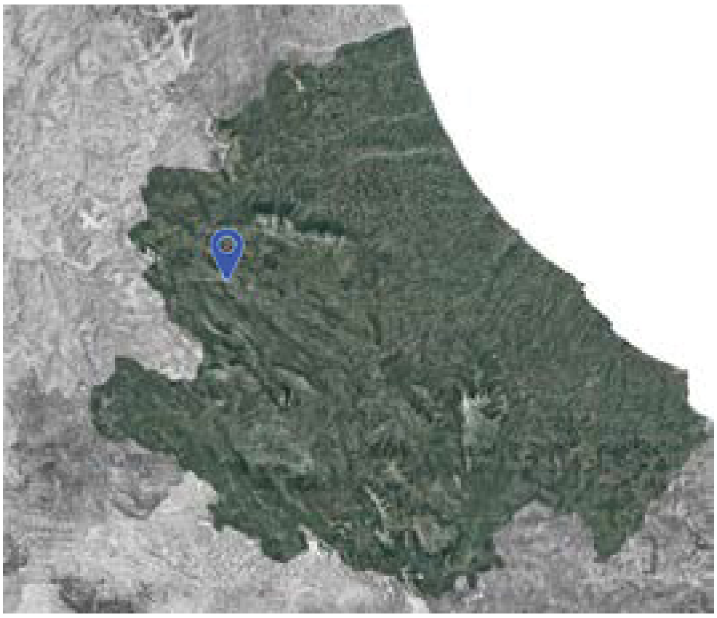
- *Carbonara (1981, 1995, 2004)*
- *Delogu (1948, 1969)*
- *Donatelli (2012)*
- *Gavini (1923)*
- *Giovannoni (1923)*
- *Moretti (1972)*
- *Munoz (1915)*
- *Pezzi (2005)*
- *R. Soprintendenza (1915)*
- *Soprintendenza (1991)*
- *AFSABAP*

CATHEDRAL OF THE SAINTS MASSIMO AND GIORGIO

L'Aquila

Description

The architecture of the facade of the cathedral has varied over time due to the collapses, mostly due to earthquakes, and the numerous renovations, going from the original gabled with three rose windows to the 19th century version with a round porch up to today's design in neoclassical style, built between the late 19th and early 20th centuries. The interior, built between 1711 and 1780 in Baroque style, is large and bright with a Latin cross plan; it is structured on a single central nave over 70 meters long flanked by side chapels communicating with each other



Code: A_1 | 10

Analyzed Restoration Intervention

Period of restoration	**1951-1958**
Client	**Curia Arcivescovile dell'Aquila**
Designer	**Inverardi Engineers (to be confirmed)**
Company	**/**

According to the damages emerged with the recent earthquake of 2009, the cathedral had been interested by the insertion of top beams and frames inside the existing masonry, which had expelled during the last quake events; according to some documentation, the dome had been completelly rebuilt in reinforced concrete. With the historical research in the Inverardi Engineers' Historical Archive, it is reported that the interventions were related to the damages involved by the "earthquakes of the Gran Sasso in 1950-1951".

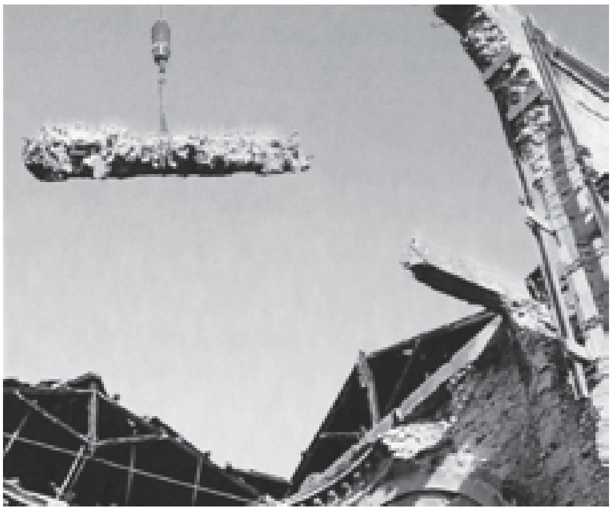


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

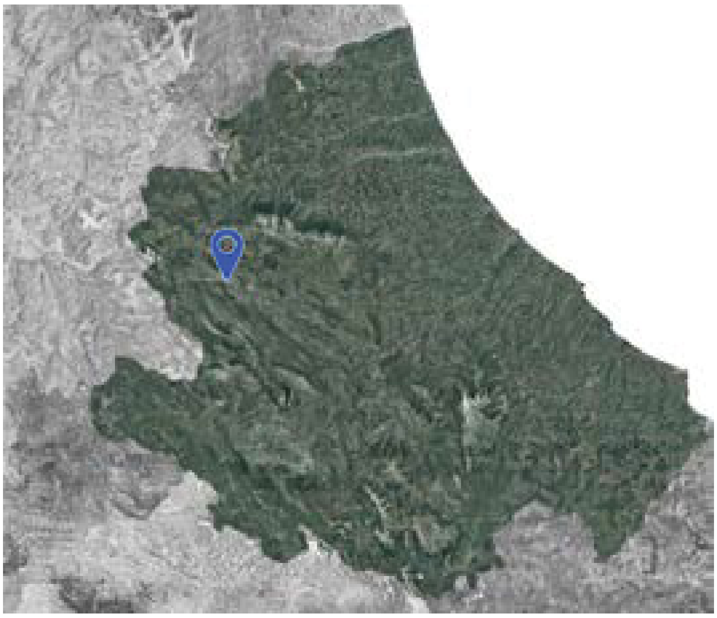
- *Alinari (1935)*
- *Leosini (1974)*
- *Lopez (1974, 1988)*
- *Marchetti (2013)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*

BASILICA OF SAN BERNARDINO

L'Aquila

Description

The basilica has a Renaissance stone facade built on a project by Cola dell'Amatrice between 1524 and 1542. It is divided into three orders with different decorative styles: the first is of the Doric order, the second Ionic and the third Corinthian. In the entablature of the first order there are depicted metopes, in the second order there is an elegant serliana, while in the third there are three large oculi. Four rows of double columns divide it vertically creating an evocative and harmonious design of nine squares on three rows. The interior has a Latin cross with three naves and is about one hundred meters long. Its baroque appearance is due to the restorations following the 1703 earthquake which razed the central nave, the dome and the drum to the ground. Today the central nave has a fine wooden, carved, painted and gilded coffered ceiling.



Code: A_1 | 11

Analyzed Restoration Intervention

Period of restoration	**1958-1961**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise Soprintendente G. Matthiae**
Designer	**S. Mioni, A. Angelini, A. Calvani, R. Iaboni**
Company	**Nicola Cingoli, Teramo**

The complex intervention aimed to restore the integrity of the facade which presented cracks and fissures. After the deassemblation of the covering elements, the foundation had been reinforced with cement injections, and also the insertion of plinth in reinforced concrete. The entire structure of the facade had been reinforced with the insertion of a frame in reinforced concrete, constituted by four columns and bond and top beams, which enveloped to the entire perimeter of the church.

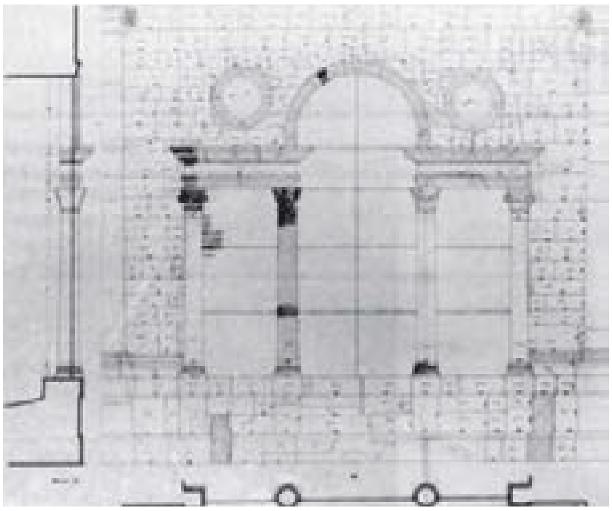


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

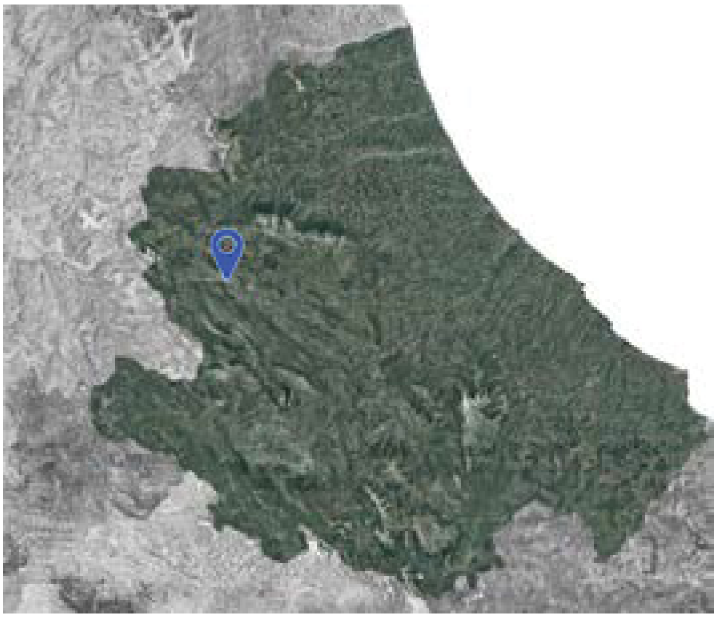
- *Antonini (1988)*
- *Bartolini Salimbeni (1993)*
- *Carbonara (1981)*
- *Centofanti (1992)*
- *Centofanti Verini (1969)*
- *Chierici (1964)*
- *Cingoli (1990)*
- *Ciranna et al. (2015)*
- *Del Bufalo (1980)*
- *Gavini (1915, 1927)*
- *Leosini (1974)*
- *Miarelli Mariani (1979)*

BASILICA OF SANTA MARIA DI COLLEMAGGIO

L'Aquila | second intervention

Description

The basilica of Collemaggio had been founded in 1287 and it rapresents one of the most important building of the city of L'Aquila. After many changes, which modified the architecture and removing the baroque decorations, the church today shows its romanic aspect. The facade, realized in the second half of the 14th century with precious geometrical weave, present three gates, decorated with arches and columns, with recesses inside which there are positioned small statues. The interior of the building is divided in three different naves, which intersect the transpet. The final apse closes the architecture. The basilica, since its foundation, had been interested by the earthquakes, which involved the modification of the structural elements. In particular, the event of 1915 involved the two analyzed restoration interventions.



Code: A_1 | 12

Analyzed Restoration Intervention

Period of restoration	**1960-1962**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise**
Designer	**Ufficio del Genio Civile**
Company	

After years of continuying decay of the structures, some of them after a local earthquake occurred in 1958, the Genio Civile proposed the demolition and the reconstruction of the dome, in incipient collapse. In this phase, from 1960 to 1962, the new element had been reconstructed completely in reinforced concrete, as also the new top perimetral beams. In particular, there were inserted two levels of beams in reinforced concrete, with a double system of base beam and horizontal beam at mid height.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

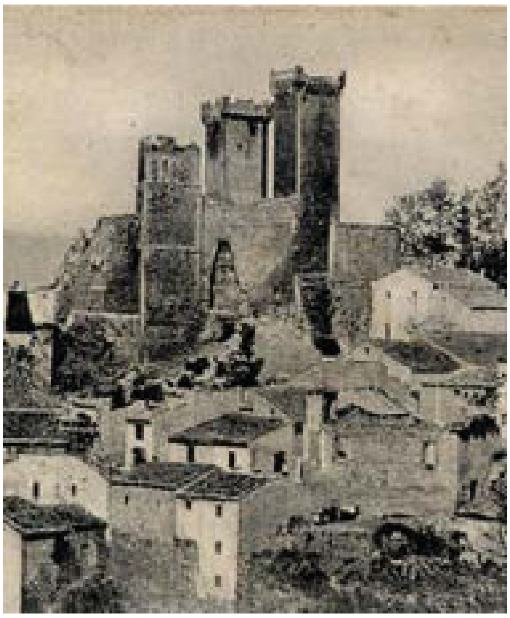
- *(2017) - Collemaggio*
- *Antonacci, Beolchini et al. (2001)*
- *Antonacci et al. (2010, 2012, 2013)*
- *Antonini (1988)*
- *Bartolomucci (2004)*
- *Carbonara (1995)*
- *Galeota, Aloisio et al. (2019)*
- *Gizzi (1988)*
- *Marchetti (2009)*
- *Miarelli Mariani (1979)*
- *Moretti (1972 a, b, c, d)*
- *Pezzi (2005)*
- *ASGCReg.*

CANTELMO CASTLE

Pacentro (AQ) | First intervention

Description

Pacentro Castle, located on the highest part of the village, at an altitude of 718 m on Mount Morrone, it is one of the best preserved fortified structures in Abruzzo. The structure has a system of two different walls: the internal one, older and therefore more ruined, and the external one, more recent and much better preserved. There are several coats of arms placed on the fortress complex, almost all difficult to read, the best preserved is a shield attributed to the Orsini, placed on the cylindrical tower at the southwest corner.



Code: A_1 | 13

Analyzed Restoration Intervention

Period of restoration	**1964**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo**
Designer	/
Company	/

The first intervention of 1960 was decidedly invasive, with works by demolition of the south-west boundary wall and other internal walls, causing damage to the N-E tower with vertical injuries from the base.

To deal with these damages, in 1964, the tower was consolidated by means of exposed concrete structures and steel elements that function as a spur and containment of the lesion. Furthermore, a reinforced concrete wall was created to compensate the gap relating to a section of the N-E boundary wall.

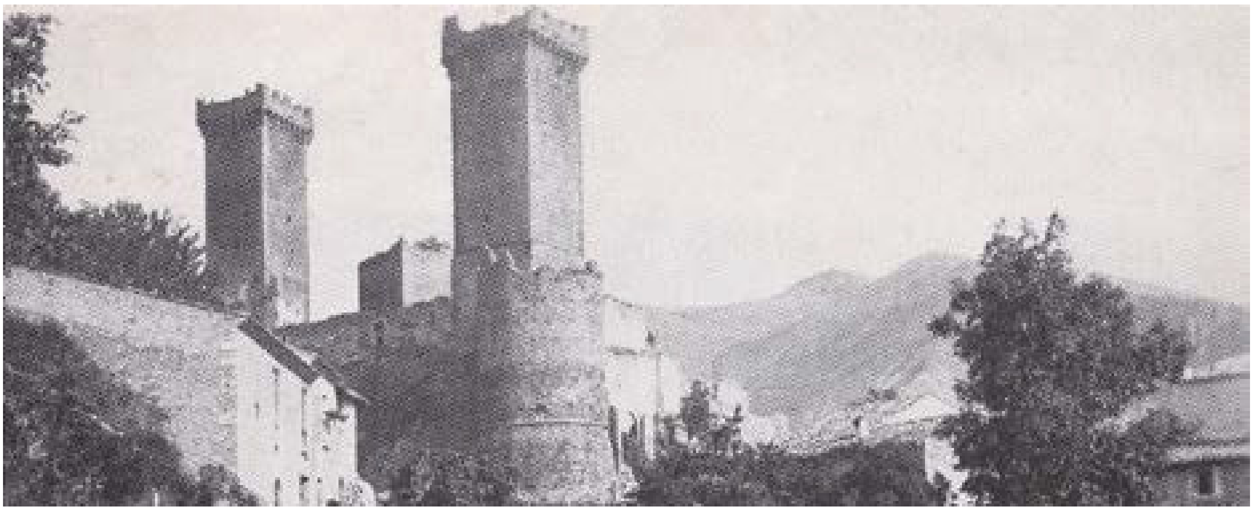


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Chiariza et al. (2002)*
- *Di Ciocco (1960)*
- *Moretti (1972)*
- *R. Soprintendenza (1915)*

CHURCH OF SANTA MARIA MAGGIORE

Pianella (TE)

Description

The church was built in the 12th century, presenting lot of interesting decorations. The pointed portal is probably the work of Maestro Acuto, and rests on two bas-reliefs with plant motifs on the left and animal motifs on the right. The architrave is richly sculpted in bas-relief with the representations of eight different characters. In the interior, the naves are divided by alternating circular and rectangular pillars, which support round arches. The choice of circular pillars reveals the Lombard influence, which can also be found in the hanging arches, in the blind arches and in the half-columns on the facade. The bell tower is divided into different levels, delimited by vertical parastes and frames with internal arches.

Code: A_1 | 14

Analyzed Restoration Intervention

Period of restoration	**1961-1967**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**A. Galvani, G. Greci**
Company	**Pio Iorio, L'Aquila | Antonio Visioni, L'Aquila**

The restoration of the church was carried out in two phases: in the first phase, the entire building envelope had been consolidated with a reinforced concrete top beam, while, in the apsidal area, it was possible to proceed with the demolition of the two 19th century buttresses between the apses , creating two reinforced concrete brackets for the wall's reinforcement. With the second phase, the restoration of the original level of the floor was completed, which allowed the rediscovery of ancient bases previously buried. Other modifications made in ancient times to the original organism had been maintained, being affected by the presence of significant cycles of frescoes.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Berteaux (1904)*
- *Bindi (1889)*
- *Calvani (1968)*
- *Carbonara (1981)*
- *De Nino (1904)*
- *Gavini (1915, 1927)*
- *Mancini (2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Poggi (1914)*
- *Salazaro (1881)*

CHURCH OF SAN BARTOLOMEO

Carpineto Della Nora (PE)

Description

The church of S. Bartolomeo belongs to the ancient abbey complex founded in 962. Only a few traces remain of the abbey premises, while the church still returns its medieval face. The facade can be attributed to the 12th century, particularly suggestive because of the portico with a dense curtain of stones, opened by two small arches arranged asymmetrically. Closely the tower bell stands a keep cause of its massive size; in addition, a wind bell tower is set on the roof at the triumphal arch of the central nave. The element of greaest interest is certainly the only portal that leads into the church. The church has a hall layout, with three naves, divided by three round arches falling on rectangular pillars, with also the same height. Three pointed arches separate the space of the longitudinal hall from the raised presbytery.

Code: A_1 | 15

Analyzed Restoration Intervention

Period of restoration	**1966-1967**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo e Molise Soprintendente M. Moretti**
Designer	**G. Greci**
Company	**Raffaele Cingoli, Teramo**

Since this is a "hall" church, it was decided to build a new roof in reinforced concrete prestressed, providing the building with a stable and relatively light protection and thus leaving the wooden roof below that had a characteristic painted plan independent. In addition, restoration works were carried out on the walls, in the places where the conditions of crumbling were most evident.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

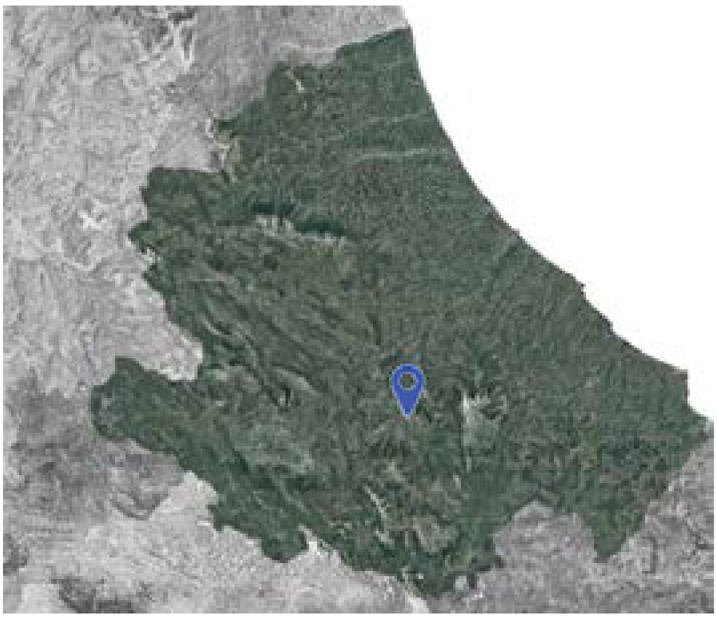
- *Abbate (1903)*
- *Bartolini Salimbeni (1993)*
- *Bindi (1889)*
- *Brusaporci (2007)*
- *Carbonara (1981)*
- *Chierici (1945)*
- *Gavini (1927)*
- *Mancini (1986, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Sabatini (1960)*

CHURCH OF SANTA MARIA DI RONCISVALLE

Sulmona (AQ)

Description

Also known by the name of Santa Maria Lungis Valle, Rosa de Vallis or, more recently, of Santa Maria Giovanna, the church was erected in the 13th century in an area formerly considered sacred in ancient times, probably dedicated to the cult of Minerva, on the site occupied in the early Middle Ages after the disappearance of the church of San Vincenzo. The place where the church stands has undergone transformations during the last century and the building is now isolated on an embankment contained by a wall. A portico leaning against the facade, covered by a barrel vault with lunettes, was subsequently added to the original layout. The only entrance arch, in square blocks, is round-headed with the emblem of the city in a key.



Code: A_1 | 16

Analyzed Restoration Intervention

Period of restoration	**1966-1967**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**M. Dander**
Company	**Carlo La Gatta, Sulmona**

The upper terminal part, completely rebuilt, does not present any decorative or structural elements of any relief. The reuse of the individual architectural elements, recovered from the heaps of rubble, allowed a re-assembly absolutely faithful to the situation prior to the collapse.

The binding works of the new wooden roof were carried out with reinforced concrete top beam; the same type of work was carried out at the top of the Gothic prothyrum, finished with a wall of limestone ashlars, instead of a wooden roof with a pitch.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

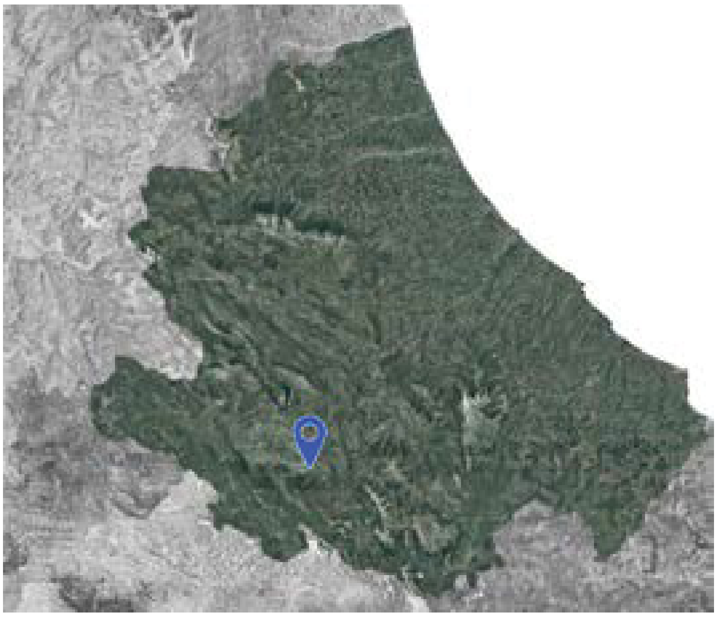
- *Abbate (1903)*
- *Donatelli (2012)*
- *Fucinese (1974)*
- *Moretti (1972)*

CHURCH OF SANT'ORANTE

Ortucchio (AQ)

Description

The Church of Sant'Orante was built around the end of the 8th century and expanded several times over the centuries; important interventions were carried out during the 18th century, although what we can admire today is the reconstruction that took place at the end of the 60s of the last century. The church was heavily damaged by the 1915 earthquake which destroyed the side aisles and significantly damaged the frescoes, leaving intact only the portal characterized by three circular columns on each side. The works have given the community back a church which, in its perspectives and spaces, follows what was the primitive building consisting of a broken gabled facade and has three rectangular windows in addition to the portal. The interior has a central nave and two lateral aisles, with a quadrangular apse. The roof has wooden trusses.

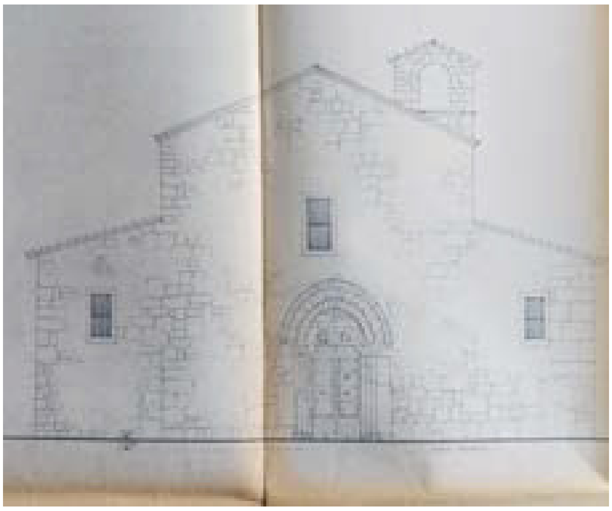


Code: A_1 | 17

Analyzed Restoration Intervention

Period of restoration	**1960-1968**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo e Molise**
Designer	**T. Delfini, G. Bevilacqua | M. Dander, A. Calvani**
Company	**L. Angelone, Avezzano**

The only truly remarkable parts, of what remained of the church demolished by the earthquake of 1915, were the lower part of the facade, with the typical Apulian-Romanesque portal, some pillars of the naves and the presbytery wall. The work was financed with contributions for the earthquake buildings and therefore supervised and directed by the Genio Civile of Avezzano. Only the artistic consultancy remained with the Soprintendenza. The remaining structures have been consolidated, then integrated with new masonry systems and reinforced concrete beams in different levels, supporting the upper part of the walls and the roof structure.



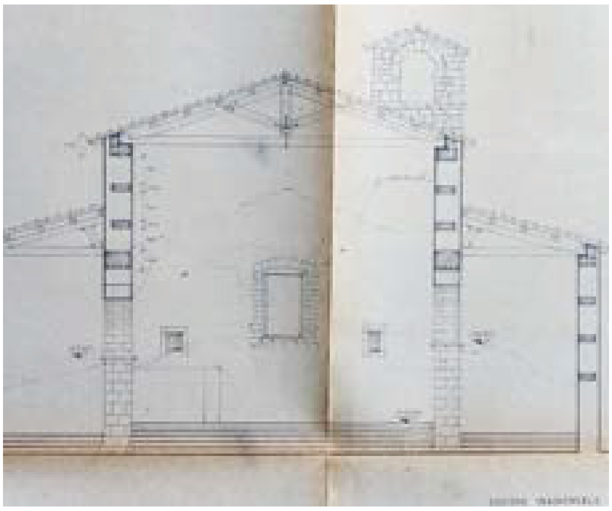


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Ciranna et al. (2015)*
- *Corsignani (1738)*
- *Donatelli (2010)*
- *Gavini (1927)*
- *Mancini (2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Piccirilli (1902)*
- *R. Soprintendenza (1915)*
- *ASGCReg_Az*

FANZAGO PALACE

Pescocostanzo (AQ)

Description

The palace has buit as a cloistered monastery intended to host the daughters of noble families in the area. What remains today of the original structure, also due to the catastrophic earthquake of the Majella of 1706, is the facade on the square, while the rest was rebuilt in new forms by other architects, so that this prospect shows itself as a fifth that closes the space behind , and defines the triangular area of the municipal square. Placed in continuity with the church of San Nicola, the facade of Fanzago, has a straight and asymmetrical trend, when it still housed the monasestery, before the suppression of 1866, the facade had no windows, due to the rules of the enclosure, therefore there are some monumental niches that alternate the closed crowning gable with the broken one.

Code: A_1 | 18

Analyzed Restoration Intervention

Period of restoration	**1967-1968**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**M. Dander**
Company	**Guastella e Castellana, Roma**

Practically abandoned for use as a school, the building had been restored in the ancient spaces.

Numerous works have been carried out: the arrangement of the rear garden, the general overhaul of the roofs, the consolidation and cleaning of the monumental niches, which give tone and character to the facade as well as, also, static interventions to restore a considerably altered balance, such as reinforced concrete top beams, with also cement injections and masonry reinforcements.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Cantone (1980)*
- *Mancini (1986)*
- *Moretti (1972)*

CHURCH OF SANTA MARIA DI CARTIGNANO

Bussi Sul Tirino (PE)

Description

The church had been founded probaaly in the 11th century by the Benedictines; abandoned during the century, it had been revaluated in the 20th century, but in complete decay due to the earthquakes. The exterior has a typically thirteenth-century appearance, consisting of a very simple facade, consisting of a minute portal with a semicircle architrave, a floral rose window, and a bell tower, as the result of reconstructions for anastylosis, after the collapse of the original. The other intact part of the church is the apse with "dentils" decorations, and the rear gabled prospect. The sides of the church are surrounded by small arches. On the left side of the church, close to a hill, there are remains of a hut that housed the hermits.

Code: A_1 | 19

Analyzed Restoration Intervention

Period of restoration	**1968-1969**
Client	**Soprintendenza ai Monumenti e Gallerie dell'Aquila Soprintendente M. Moretti**
Designer	**R. Mancini**
Company	**Antonio Visoni, L'Aquila**

The intervention of the Soprintendenza ai Monumenti e Gallerie dell'Aquila consisted in the reinforcement of the walls, aiming also to find the original ground level. The insertion of hidden reinforced concrete buttresses aimed to avoid the rotations of the facade, resuming the facing with exposed masonry, and also roof, the aisles and the apse were returned, thanks to a reinforced concrete top beams on the arches of the central nave.

Table of restoration's cataloguing

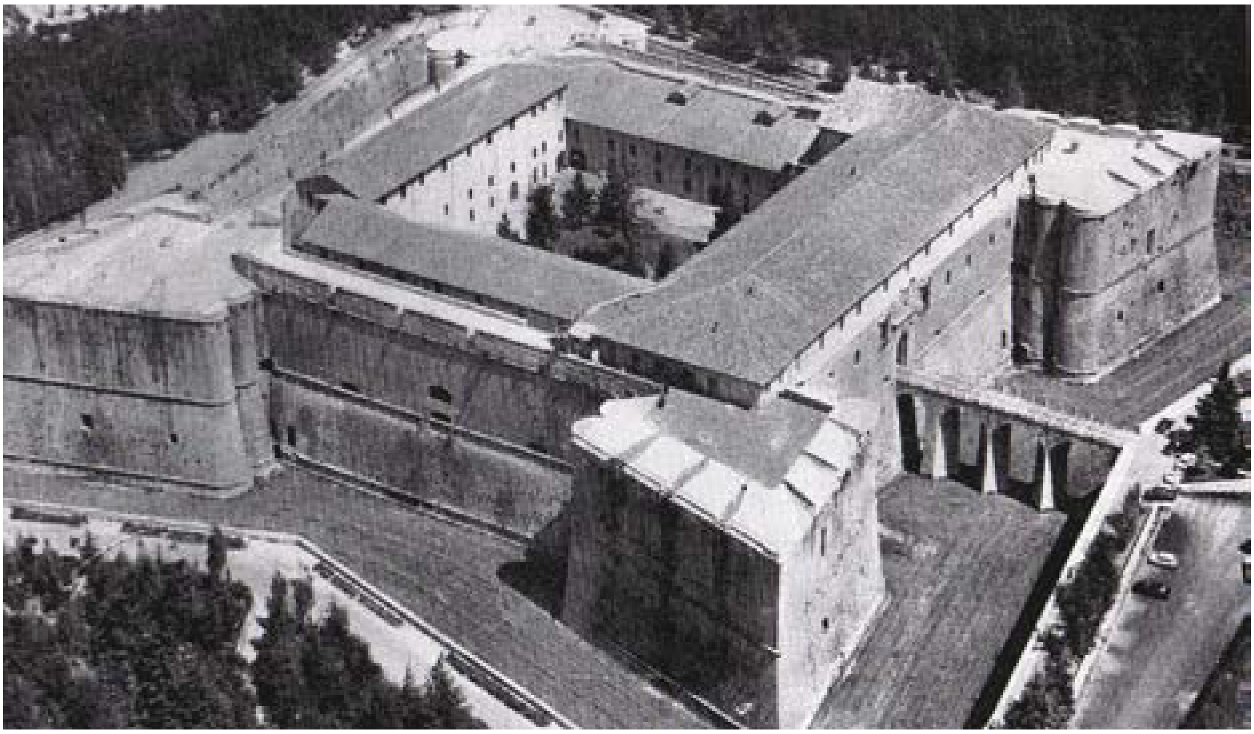
PHASE 0	**Earthquake**	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Berteaux (1904)*
- *Brusaporci (2007)*
- *Carbonara (1981)*
- *Chierici (1945)*
- *Gavini (1927)*
- *Mancini (1986, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*

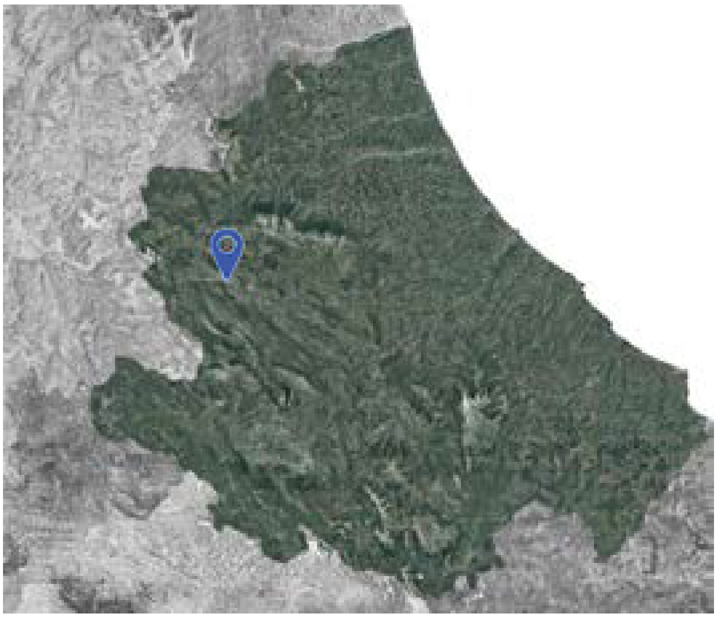
FORTE SPAGNOLO

L'Aquila



Description

The imposing fortress, built following the most up-to-date fortification techniques of the 16th century, has a square plan, with at the four massive corners bastions with sharp profiles with a spearhead scheme, each in the direction of the four cardinal points. Built on the rock, the castle has considerable thicknesses in the walls, ranging from ten meters to the foundation, to five meters at the top of the curtain. Except of the precious stone portal, there are no other decorations. The internal courtyard has a square shape. The south-east side, corresponding to the entrance, shows a double order portico of pilasters, which in the original projects probably extended to the entire perimeter of the courtyard.



Code: A_1 | 20

Analyzed Restoration Intervention

Period of restoration	**1950-1970**
Client	**Soprintendenza ai Monumenti e Gallerie dell'Aquila Soprintendenti U. Chierici | M. Moretti**
Designer	**A. Calvani | M. Dander**
Company	**Antonio VIsioni, L'Aquila | OMAR Roma**

The restoration interested the creation of new volumes, with the new spaces for the Soprintendenza, the Museum, the concert hall and an institute for the university of L'Aquila. In this restoration, the role of reinforced concrete is evident in the reinforcement of the underground spaces, obtained at the base level with the covering of the walls with structures in reinforced concrete. Furthermore, the new roofing systems had been realized in timber, with perimetral top beam in reinforced concrerete.

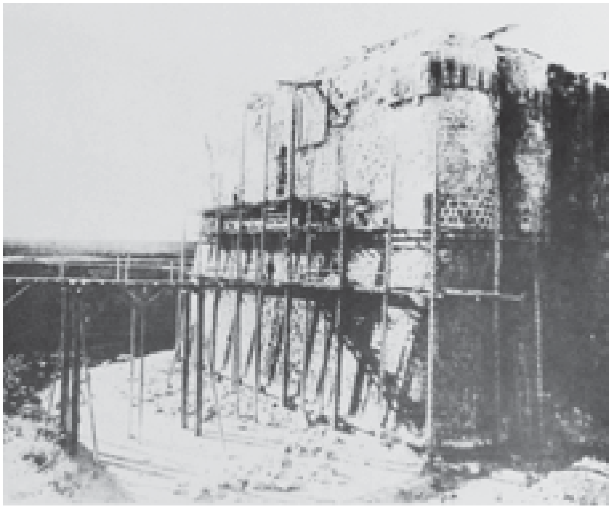


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Badiali (1912)*
- *Carbonara (1981)*
- *Chierici (1945, 1951)*
- *Ciranna (2003, 2015)*
- *Eberhardt (1994)*
- *Franchi (1965)*
- *Gavini (1927)*
- *Jurgen (1973)*
- *Matthiae (1959)*
- *Miarelli Mariani (1979)*
- *Moretti (1972, 1974)*
- *Pezzi (2005)*

CONVENTO OF SAN FRANCESCO

Fontecchio (AQ)

Description

The monastic complex was erected in 1268 next to an existing church dedicated to Sant'Agnese and not far from the Benedictine monastery of S. Maria Agraiano of S. Pio. Today the building is the result of a series of interventions that have over the centuries. The church has a single-nave plan with a cross-vaulted square choir, while the fairly large rectangular hall is covered by barrel vaults with slightly lowered arches. The presbytery area can certainly be considered as belonging to the 14th century church; following a restoration, on the wall where the triumphal arch opens. On the unfinished facade of the church, the sixteenth-century rose window and portal open, probably reassembled after the expansion of the 17th century church.

Code: A_1 | 21

Analyzed Restoration Intervention

Period of restoration	**1965-1970**
Client	**Soprintendenza ai Monumeti degli Abruzzi e Molise** **Soprintendente M. Moretti**
Designer	**A Calvani | M. Dander**
Company	**Duilio Miocchi, L'Aquila**

The first phase of the restoration involved the eastern side of the cloister, with the dismantling of the entire upper floor and the creation of a large continuous reinforced concrete truss, on the acute arches of the first order, in a way to connect and support the walls. In the church, the intervention was limited to the construction of a new brick floor and the remaking of the roof covering; characterized by an identical alternation of full and empty spaces, difficult due to the state of dilapidation of the wall structures, which have been revitalized with reinforced concrete top beams, the upper loggia was restored only in few part of the building, while the rest was reinforced in the ruin state.

Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Barbato et al. (1978)*
- *Carbonara (1981, 1995)*
- *Clementi et al. (1986)*
- *Comunità montana (1985)*
- *De Nino (1904)*
- *Gavini (1927)*
- *Mancini (1986)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Rivera (1902)*

SHRINE OF SANTA MARIA DI PIETRAQUARIA

Avezzano (AQ)

Description

The Sanctuary is located on Mount Salviano, 1,000 meters above sea level, and it had been founded probably in the 12th century. Saved from the earthquake of the 1915, in 1968-1969 the Sanctuary was further enlarged and transformed. The current layout is a Latin cross with a single nave, with a choir behind the presbitery. The facade is plastered in white with four small buttresses supporting a golden mosaic cornice. The bell tower on the left is a tower without a spire in rough stone. Next to the bell tower there is a portico which ends in an irregular rectangular building which is the home of friars and pilgrims.

Code: A_1 | 22

Analyzed Restoration Intervention

Period of restoration	**1967-1970**
Client	**Soprintendenza Monumenti e Gallerie dell'Aquila Soprintendente m. Moretti**
Designer	**G. Greci**
Company	**/**

Completely rebuilt after the earthquake of 1915,the restoration aimed to the static consolidation intervention, carried out by the Soprintendenza and financed by the Cassa per il Mezzogiorno in the years 1967-1970. In the presbytery area, in relation to the annular hall therein, a reinforced concrete framework was created inside the load-bearing walls, in order to support the structure of the ambulatory by hooking it to the skeleton of the apse. The works were completed in March 1970

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
	Decay	Top and bond beams' insertion
PHASE 2	War	Reinforced concrete frame's insertion
PHASE 3	Reinstatement	Foundations

References

- *Brogi (1954)*
- *Carbonara (1981)*
- *Jetti (1978, 2016)*
- *ADM*

CHURCH OF SAN FRANCESCO

Celano (AQ)

Description

The Church of San Francesco in Celano is a 14th century building. The facade was built only two centuries later, a median frame divides it horizontally into two sections. The interior has the late Baroque aspect given to it by the 18th century renovation, in which white and gold are the dominant colors. With a single nave, it is embellished with paintings on canvas from the 16th to the 18th century and stone slabs

Code: A_1 | 23

Analyzed Restoration Intervention

Period of restoration	**1969-1970**
Client	**Soprintendenza Monumenti e Gallerie d'Abruzzo e Molise** **Soprintendente M. Moretti**
Designer	**M. Dander**
Company	**Domenico Visca, Roma**

The church, badly damaged by the 1915 earthquake, had been restored, after the earthquake, with a reductive and unsatisfactory solution. The new intervention has only marginally concerned the restoration of the external vestments, resumption of the internal coloring, while it has resolved the static problem with the insertion, inside the old perimeter walls, of a system of thin reinforced concrete frames anchored to a crowning top beam, always in reinforced concrete; the transversal connection was ensured with the restoration of the roofs, by means of the execution of a reinforced brick floor and overlying slab on reinforced concrete trusses recessed in the same top beam.

Table of restoration's cataloguing

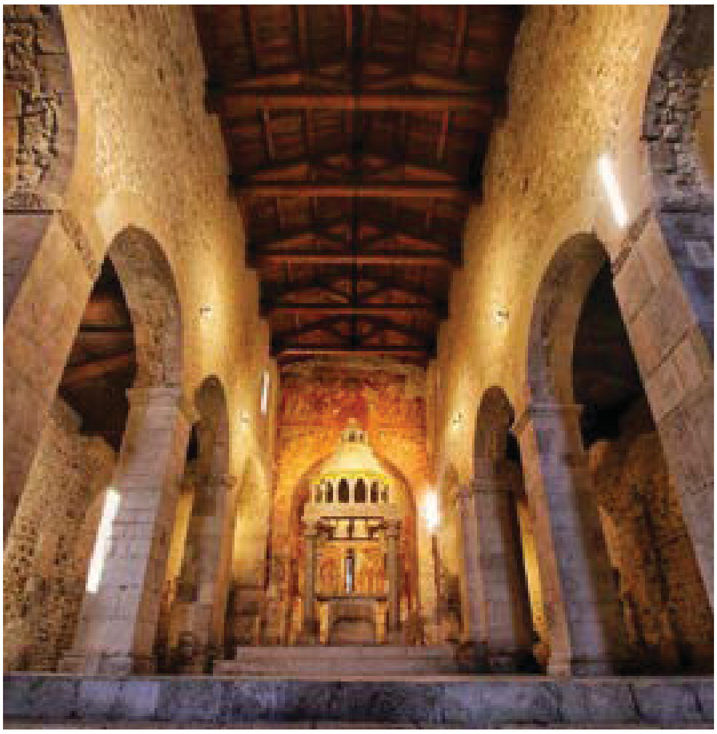
PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Mancini (2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Munoz (1915, 1916)*
- *Pezzi (2005)*

CHURCH OF SAN PIETRO AD ORATORIUM

Capestrano (AQ)



Description

The church, the only remnant of an ancient monastic structure, stands in an isolated position in the Capestrano countryside; it constitutes an important testimony of that artistic and cultural penetration which, at the end of the 11th century and in the first half of the 12th, took place in Abruzzo by the Benedictines of Cassino. The building is structured in three naves divided by arches on pillars, with a very regular square block wall fixture, installed without mortar joints - according to a deliberate imitation of classical wall techniques - and also with rich ornamental elements , distinguished by a strong desire to reinterpret the ancient formal heritage.

Code: A_1 | 24

Analyzed Restoration Intervention

Period of restoration	**1970**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise** **Soprintendente M. Moretti**
Designer	**R. Mancini**
Company	**Antonio Visioni, L'Aquila**

In defense of the infiltration of water, the intervention provided the construction of a slab in reinforced concrete. The columns have been underpinned with reinforced concrete plinths, up to a depth of 1.5 m and, in the upper level, interested by the insertion of a reinforced concrete top beam. For the execution of this application, it had been necessary to disassemble the exposed elements of each column and then reassemble them in the exact original position. The upper part of the façade and the walls of the aisles were reconstituted, so as it was also necessary to base the perimeter walls in with elements in reinforced concrete, up to a depth of 1.5 m.

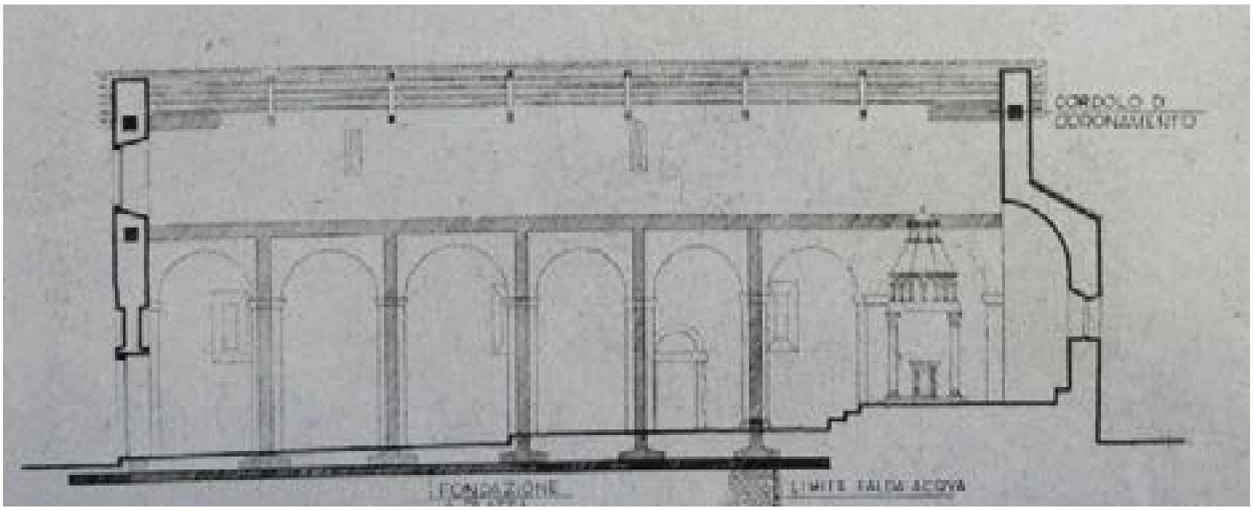


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Bertaux (1904)*
- *Brusaporci (2007)*
- *Carbonara (1981)*
- *Chierici (1945)*
- *Gavini (1927)*
- *Giovannoni (1924)*
- *Mancini (1986, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pace (1971)*
- *Pezzi (2005)*
- *Poggi (1914)*

CHURCH OF SAN LIBERATORE A MAIELLA

Serramonacesca (PE)

Description

The church has a white facade balanced in volumes and flanked by a square bell tower developed in three floors, which present mono-mullioned windows, bi-mullioned windows and three-mullioned windows. The internal division of the basilica is made up of three naves with seven all-round arches that insist on triangular pillars. The presbytery is accessed through three triumphal arches (the central one is missing), which rest on cross-shaped columns and end with oval and denticulate decorations; this same type of decoration divides the walls of the central nave horizontally up to the apse, ending in three circular orders. The ceiling has wooden trusses.

Code: A_1 | 25

Analyzed Restoration Intervention

Period of restoration	**1967-1971**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo Soprintendente M. Moretti**
Designer	**G. Greci**
Company	**Antonio Visioni, L'Aquila**

The facade, very deteriorated, had widespread lesions due to the continuous disruptive action of the frosts. The terminal part of the bell tower was very damaged and lacking of the roof. The masonry walls were strengthened by introducing reinforced concrete top beams and foundation elements; the roof has been rebuilt with exposed wooden beams. In the apsidal area, the vaulted ceilings and the wall facing were consolidated in in reinforced concrete. In the bell tower, consolidated with reinforced concrete top beams, the roof was redone and the upper triple lancet window was reinstated.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Balzano (1911)*
- *Carbonara (1981)*
- *Ciranna et al. (2015)*
- *Donatelli (2010)*
- *Fucinese (1980)*
- *Gavini (1915, 1927)*
- *Mancini (1986, 2004)*
- *Matthiae (1963)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Verlengia (1958)*

CHURCH OF SAN DOMENICO

Teramo

Description

The church is presented in the guise of restoration and reconstruction of the early 20th century. The structure and facade are made of brick, while the stone portal with a lunette bearing some fragments of fresco. The interior has a single nave with a double pitched roof, without a transept and completed by a square vaulted choir (typical of the churches of the beggar orders built between the end of the 13th century and the beginning of the 14th century). The pointed arches of the interior support the roof trusses.

Code: A_1 | 26

Analyzed Restoration Intervention

Period of restoration	**1968-1971**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**G. Greci**
Company	**Nicola Cingoli, Teramo**

The project proposed the static restoration of the structure in its existing aspect. The works concerned the execution of hooks between the perimeter mutation structures and the transverse arches, which in some points were detached by more than 20 cm; the connection of the longitudinal walls was ensured by means of a new reinforced concrete roof, which was however made above the existing wooden roof, which was therefore left visible.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	**New roof in reinforced concrete**
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Bartolini Salimbeni (1993)*
- *Carbonara (1981)*
- *Cingoli (1990, 2009)*
- *Gavini (1915, 1927)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Savini (1929, 1931)*

CHURCH OF SANTA MARIA A VICO

Sant'Omero (TE)

Description

The façade shows itself in its essential simplicity, aligned with the bell tower, is open in the central area by a single entrance door and ends with a flat termination. In the central space there is the rose window added during the 19th century restoration. The liturgical hall, paved in terracotta, develops its conformation from an elongated rectangular plan, marked by three naves, which end with a semicircular apse opened by a single lancet window in the central area.

Code: A_1 | 27

Analyzed Restoration Intervention

Period of restoration	**1970-1971**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente Moretti**
Designer	**G. Greci**
Company	**Raffaele Cingoli, Teramo**

The project provided the consolidation of the foundation of the columns, with a reinforced concrete frame and armed slab; the restoration of the columns, of pillars and arches interested their reinforcement; wall recovery and the reconstruction of parts of the walls of the central nave, with a top beam in reinforced concrete, for the roof shutter.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

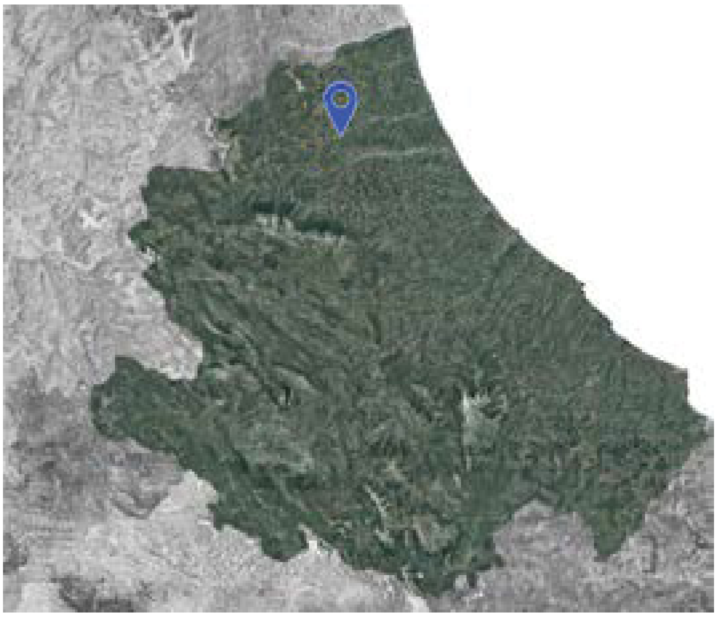
- *Brogi (1902)*
- *Carbonara (1981)*
- *Cingoli (1990, 2009)*
- *De' GUidobaldi (1908)*
- *Gavini (1927)*
- *Miarelli Marini (1979)*
- *Moretti (1972)*
- *Rasicci (1912, 1972)*
- *Sabatini (1960)*
- *Sacconi (1902)*
- *Sgattoni (1975, 1980)*

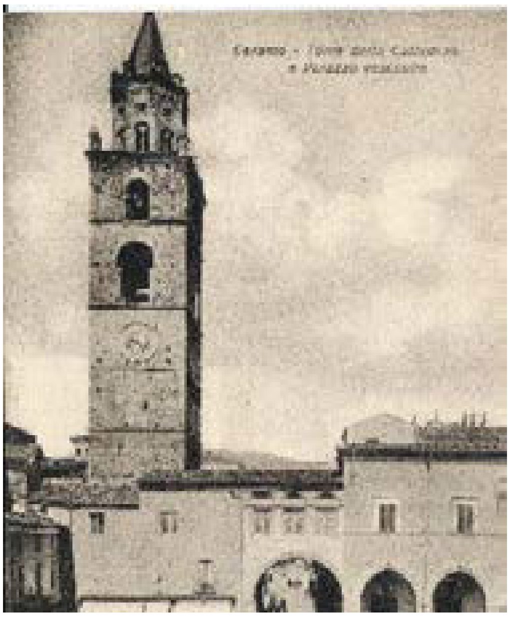
TOWER BELL OF THE CATHEDRAL OF SANTA MARIA ASSUNTA

Teramo

Description

The cathedral was completed and consecrated in 1176, in Romanesque style it had three naves, a salient facade, a trussed roof and an octagonal central lantern. The tower is about 50 meters high and it is entirely divided into overlapping modules, built in different periods, marked by string course frames. Bi-mullioned windows are placed on the third and fourth module, while the fifth and sixth houses the bell cells. Above the second bell cell, Antonio da Lodi created a roof terrace, equipped at the four corners with turrets decorated with the same ornamental motif present in the support frame of the terrace itself. At the center of it, therefore, raised the octagonal prism surmounted by the crowning pyramid, above which the metal sphere and the wind vane were installed.





Code: A_1 | 28

Analyzed Restoration Intervention

Period of restoration	**1962-1972**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo**
Designer	**G. Greci**
Company	**Duilio Miocchi, L'Aquila**

The tower, following the creation of an underpass, had manifested serious static instabilities due to the elimination of the natural abutments. The intervention provided the casting of a reinforced concrete reinforcement all around the part of the tower originally buried. The concrete reinforcement was then lined with stone slabs equal to that used in the Cathedral. Then there have been realized the compensation of the fissures , the resumption of the wall facing and the general consolidation had been pursued with top beam in reinforced concrete at the upper levels of the tower.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

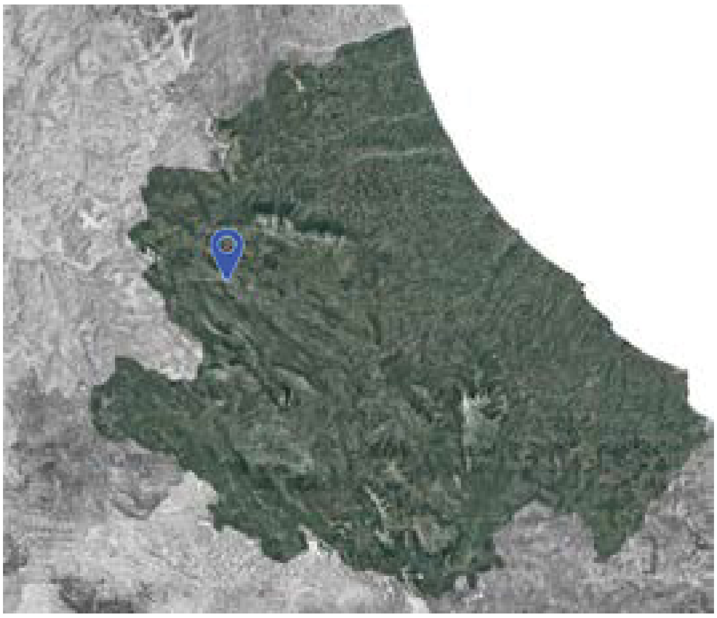
- *De Patre (1931)*
- *Dorante (1999)*
- *Eugeni (1998)*
- *Giampiero (1896)*
- *La valle del medio... (1986)*
- *Miarelli Mariani (1979)*
- *Penna et al. (1980)*
- *Pirocchi (1908)*
- *Riccoboni (1933 a,b)*
- *Salvoni Savorini (1933)*
- *Savini (1926, a,b,c,d)*
- *Tiboni et al. (2000, 2002, 2004)*

BASILICA OF SANTA MARIA DI COLLEMAGGIO

L'Aquila | third intervention

Description

The basilica of Collemaggio had been founded in 1287 and it rapresents one of the most important building of the city of L'Aquila. After many changes, which modified the architecture and removing the baroque decorations, the church today shows its romanic aspect. The facade, realized in the second half of the 14th century with precious geometrical weave, present three gates, decorated with arches and columns, with recesses inside which there are positioned small statues. The interior of the building is divided in three different naves, which intersect the transpet. The final apse closes the architecture. The basilica, since its foundation, had been interested by the earthquakes, which involved the modification of the structural elements. In particular, the event of 1915 involved the two analyzed restoration interventions.



Code: A_1 | 29

Analyzed Restoration Intervention

Period of restoration	**1970-1972**
Client	**Soprintendenza ai Monumenti e Gallerie di Abruzzo e Molise** **Soprintendente M. Moretti**
Designer	**M. Dander**
Company	**Duilio Miocchi**

The last analyzed restoration intervention had been pursued by Mario Moretti. The project aimed to redefine the "supposed" original aspect of the basilica, removing the baroque decorations and the ceiling coffer of the main nave, giving back the "clean surfaces of the medieval walls" . The work by Moretti interested also the some structural elements of the church, letting the reopening of the rose window of the façade, the recreation of two columns in the intersection among the main nave and the transept, rebuilt in masonry, and also the sopraelevation of the walls. In this last case, the project provided also the insertion of reinforced concrete beams.

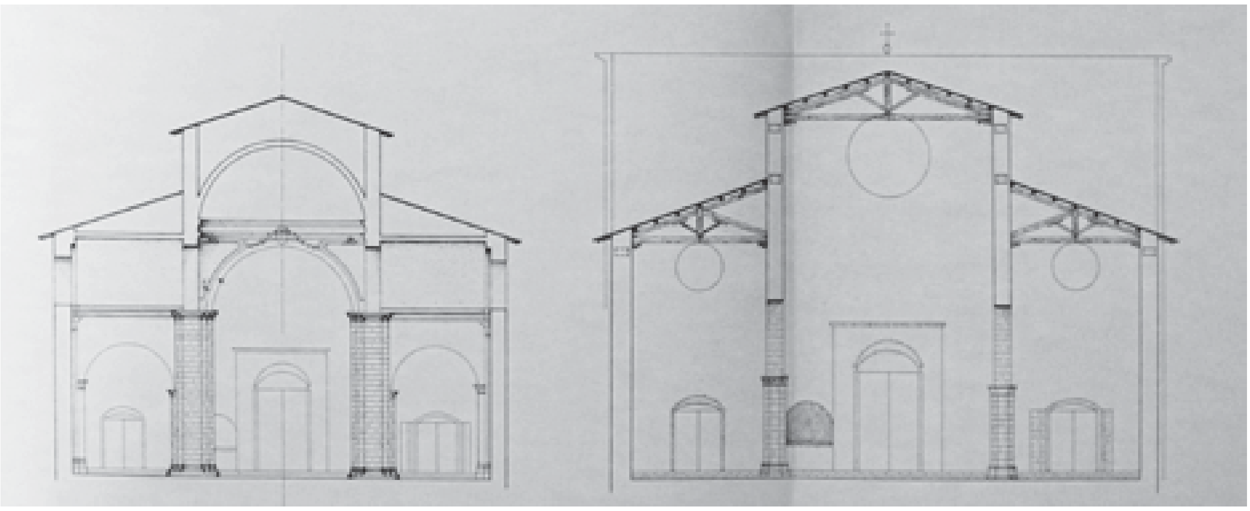


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
	Decay	Top and bond beams' insertion
PHASE 2	War	Reinforced concrete frame's insertion
PHASE 3	Reinstatement	Foundations

References

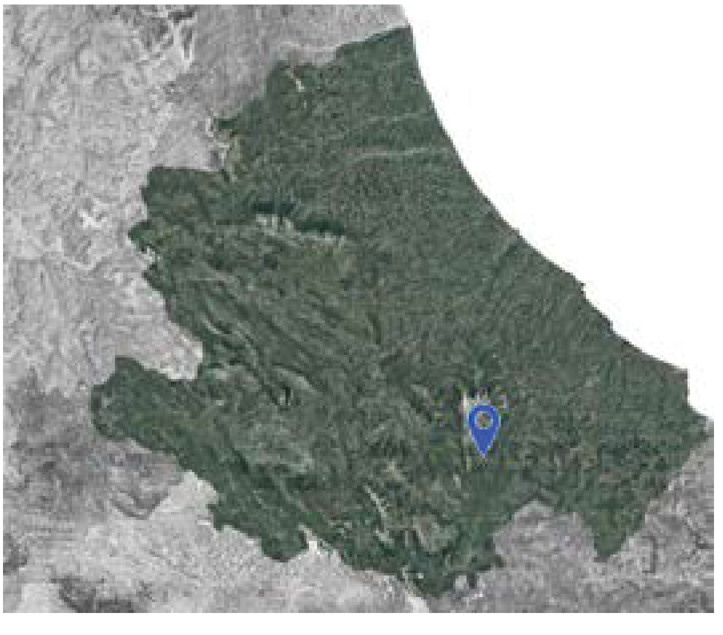
- *(2017) - Collemaggio*
- *Antonacci, Beolchini et al. (2001)*
- *Antonacci et al. (2010, 2012, 2013)*
- *Antonini (1988)*
- *Bartolomucci (2004)*
- *Carbonara (1995)*
- *Galeota, Aloisio et al. (2019)*
- *Gizzi (1988)*
- *Marchetti (2009)*
- *Miarelli Mariani (1979)*
- *Moretti (1972 a, b, c, d)*
- *Pezzi (2005)*
- *ASGCReg.*

DUCAL PALACE (CASTLE)

Palena (CH)

Description

The building had been built in the 12th century, and in the following centuries it has been remodeled several times because of violent earthquakes in the surrounding areas; one of these shocks occurred in 1933, involving various damages to the building, including the destruction of the towers, the walls and the belvedere. The plane is rectangular resulting from the union of the various buildings. Windows, also rectangular, are arranged on two levels. A loggia with four arches is located on one of the longer sides, while on the opposite side there is a series of four arches. The entrance to the castle is possible through an urban door that has a single round arch. On the opposite side there is an architraved portal with a molded frame and geometric designs.



Code: A_1 | 30

Analyzed Restoration Intervention

Period of restoration	**1971-1972**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**A. Angelini**
Company	**Duilio Miocchi, L'Aquila**

The building, before the restoration by Moretti, had been recovered, with the reconstruction of some of the collapsed parts. The company Duilio Miocchi started the restoration works in 1971, concluding the year later, with and the project had been designed by the architect A. Angelini. Aiming to make in safe the entire structure, there were realized top beams in reinforced concrete of the entire building and the base wall at the rock spur had been reinforced.

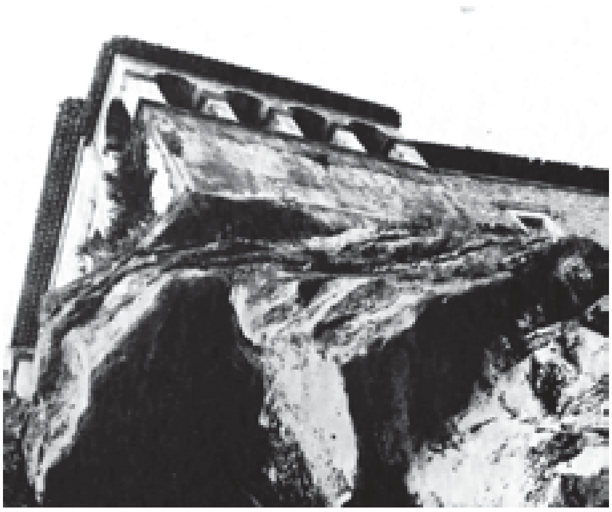


Table of restoration's cataloguing

PHASE 0	**Earthquake**	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	**War**	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Carbonara (1981)*
- *De Nino (1904)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Sabatini (1960)*

CHURCH OF SAN TOMMASO

Caramanico Terme (PE)

Description

The building presents a system based on three naves, readable also from the facade. In the front, the main portal and the rose window stand out in the center, while in the lateral sectors the smaller portals and the windows of different size and decoration. The partition of the three portals, with unloading arch, architraves and jambs, is typically Benedictine. On the architrave of the main portal, the high relief of the blessing Christ with the twelve apostles stands out. The columns of the same portal are decorated with floral motifs, a theme that is also repeated in the isolated panels of the facade. The interior of the church has a raised presbytery, a semicircular apse and a trussed roof.

Code: A_1 | 31

Analyzed Restoration Intervention

Period of restoration	**1968-1973**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**G. Greci**
Company	**Sabatino Fiordigiglio, Paganica**

The works were intended to remove the additions, freeing the late 12th century building, restoring its original appearance in substance. The static restoration of the building was carried out by means of a containment trench which, for a considerable height, had invested the presbyterial part, giving rise, among other things, to serious infiltrations of humidity; in addition, continuous reinforced concrete foundation structures were built and some damaged walls were restored with reinforced concrete top beams. The right wall has been rebuilt; the bell tower, leaning to the left of the apse and built relatively recently, was demolished and rebuilt in an isolated position.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Bindi (1889)*
- *Carbonara (1981)*
- *Gavini (1927)*
- *Mancini (1986, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pace (1971)*
- *Pezzi (2005)*
- *Sprega (1902)*

CHURCH OF SAN CLEMENTE AL VOMANO

Guardia Vomano (Notaresco Municipality | TE)

Description

The church has a Romanesque-style facade, which rises simple and austere, open in the central area by an important portal and a single lancet window above, ending with a sloping crowning. On the sides there are the brick spurs of the buttresses added to consolidate and give greater stability to the balance of the church. The church retains its bell tower, while the apses with a series of pilasters and blind arches can be seen in the rear elevation of the religious building. The interior of the church is made up of a single room with a basilical plan marked by three naves that end with three semicircular apses. The spans of the naves follow one another with round arches supported by columns and pillars of various workmanship. The presbytery is raised and the roof is divided into a roof with exposed wooden trusses.

Code: A_1 | 32

Analyzed Restoration Intervention

Period of restoration	**1970-1973**
Client	**Soprntendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente M. Moretti**
Designer	**G. Greci**
Company	**Antonio Visioni, L'Aquila**

The main reason according to which the monument had been propped up with widespread buttresses and tied by metal chains, lies in the clayey, unstable nature of the ground. With the creation of a reinforced concrete platform, which evenly distributes the weight of the building over a surface greater than that of the wall sections, the premise was laid for the release of all superstructures that alter the line of the facade and apses.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

Abbate (1903)
Bartolini Salimbeni (1993)
Bertaux (1904)
Bologna (1986)
La valle del medio e basso (1986)
Gavini (1927)
Giovannoni (1924)
Mancini (1986, 2004)
Miarelli Mariani (1979)
Moretti (1972)
Pezzi (2005)
Poggi (1914)

CANTELMO CASTLE

Pacentro (AQ) | Second intervention

Description

Pacentro Castle, located on the highest part of the village, at an altitude of 718 m on Mount Morrone, it is one of the best preserved fortified structures in Abruzzo. The structure has a system of two different walls: the internal one, older and therefore more ruined, and the external one, more recent and much better preserved. There are several coats of arms placed on the fortress complex, almost all difficult to read, the best preserved is a shield attributed to the Orsini, placed on the cylindrical tower at the southwest corner.

Code: A_1 | 33

Analyzed Restoration Intervention

Period of restoration	**1974**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo**
Designer	/
Company	/

In 1974 there were new interventions, among which the consolidation of the medieval towers, of the towers, and of the surrounding walls with foundation works, in cement conglomerate and in brick masonry; the construction of reinforced concrete structures such as pillars, curbs and beams; partial restoration and restoration of the dilapidated masonry of the stone and brick curtain.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Chiariza et al. (2002)*
- *Di Ciocco (1960)*
- *Moretti (1972)*
- *R. Soprintendenza (1915)*

CANTELMO CASTLE

Pacentro (AQ) | Third intervention

Description

Pacentro Castle, located on the highest part of the village, at an altitude of 718 m on Mount Morrone, it is one of the best preserved fortified structures in Abruzzo. The structure has a system of two different walls: the internal one, older and therefore more ruined, and the external one, more recent and much better preserved. There are several coats of arms placed on the fortress complex, almost all difficult to read, the best preserved is a shield attributed to the Orsini, placed on the cylindrical tower at the southwest corner.

Code: A_1 | 34

Analyzed Restoration Intervention

Period of restoration	**1977-1978**
Client	**Soprintendenza ai Monumenti e Gallerie d'Abruzzo** **Soprintendente Moretti**
Designer	/
Company	/

After the two interventions, it had become necessary to consolidate the southern part, in particular the wall and the tower to the southeast, threatening to collapse. The intervention provided the insertion of some reinforced concrete "cages".

The unsafe wall had been dismantled and replaced with a reinforced concrete wall, covered with the segments previously removed; the tower instead, to prevent a collapse to the base, is reinforced at the base by inserting a group of spurs, always in reinforced concrete).

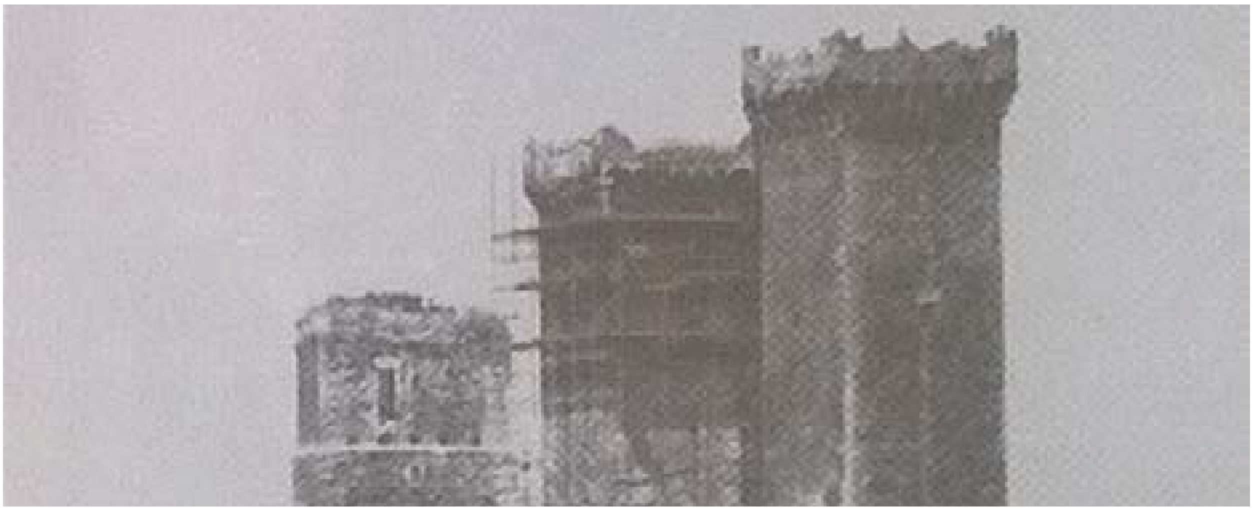


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

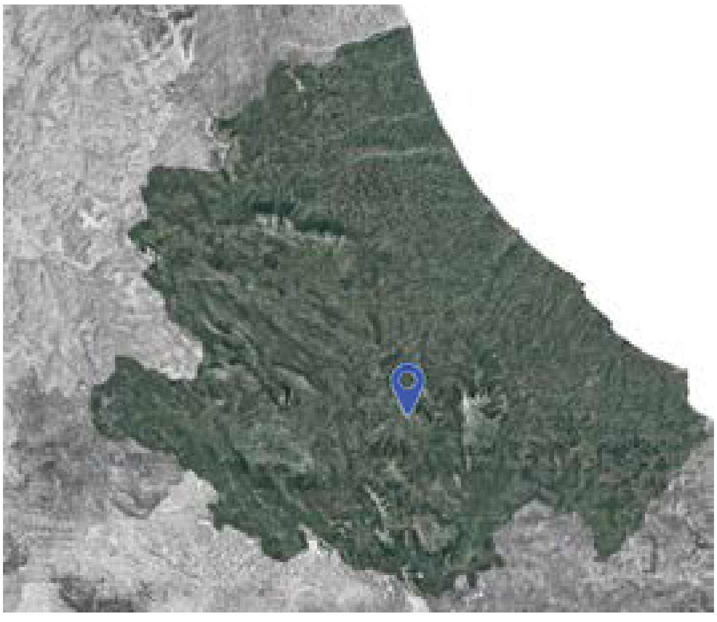
- *Abbate (1903)*
- *Chiariza et al. (2002)*
- *Di Ciocco (1960)*
- *Moretti (1972)*
- *R. Soprintendenza (1915)*

FORMER CLOISTER OF SANTA CHIARA

Sulmona (AQ)

Description

The entire monastic complex occupies a large area that from the ancient Piazza Maggiore, in the background, reaches with its fields to lap the eastern part of the 14th century city walls, built to enclose the new villages in formation. It develops on a quadrilateral and includes the church open to the faithful, with the chapel for internal use behind it, the bell tower, the actual conventual building, organized on two floors around a rectangular cloister, the parlor and some pertinent houses that overlook a square-churchyard. The place was repeatedly rebuilt, restored and enlarged, both to meet the growing needs of space and because of the damage caused by the terrible earthquakes that hit the city, especially in 1456 and 1706



Code: A_1 | 35

Analyzed Restoration Intervention

Period of restoration	**1981-1984**
Client	**Società Cooperativa Habitat Recupero s.r.l.**
Designer	**M. Bentivoglio**
Company	/

The project provides for the consolidation of the masonry for roofing in an anti-seismic function, through the insertion of a reinforced concrete top beam inside the thickness of the walls, with "dovetail" hooks for the entire section, every three meters. The chosen method allows to carry out the consolidation without dismantling the load-bearing structure of the roof; the trusses themselves are anchored with iron brackets to the top beam, thus canceling the risk that they can act as dynamically pushing elements in the event of an earthquake.

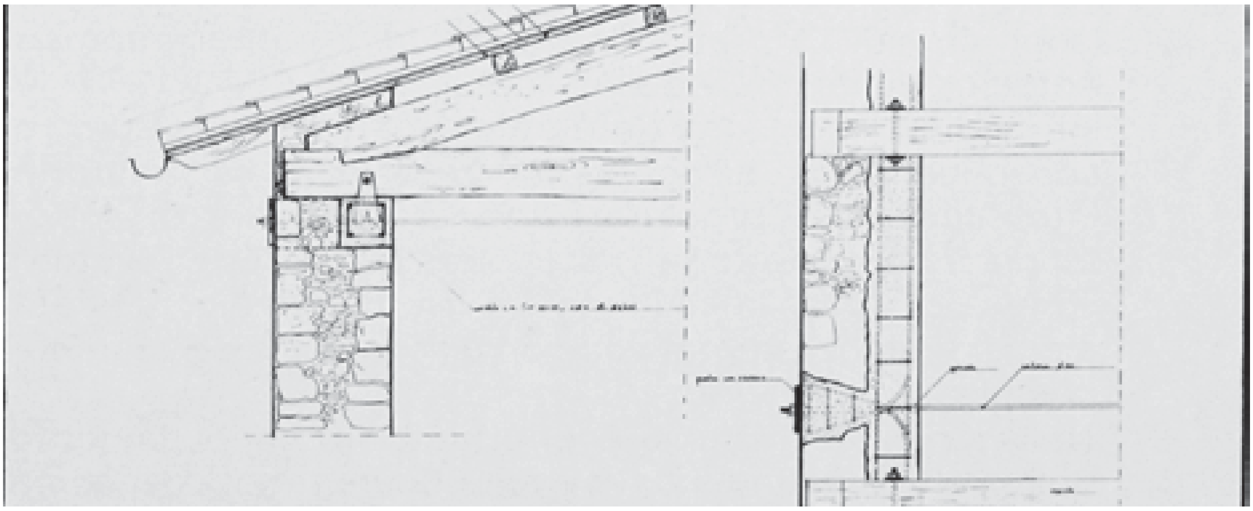


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

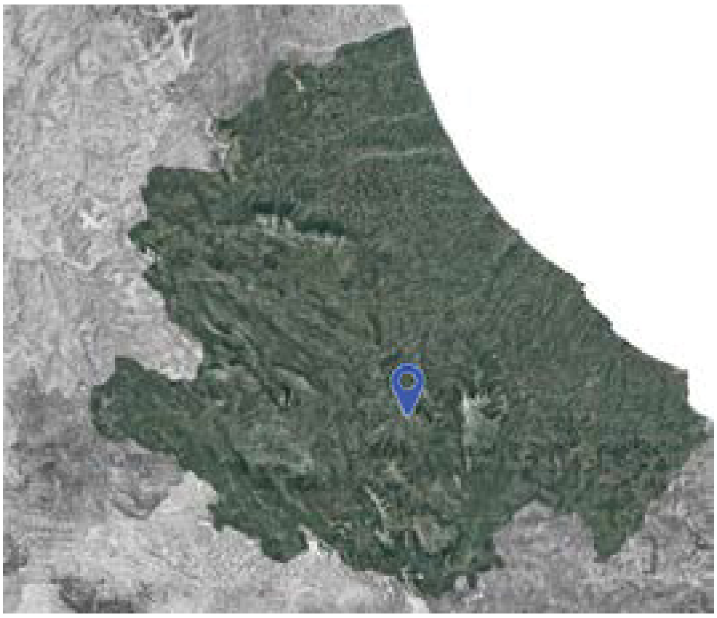
- *Abbate (1903)*
- *Bartolini Salimbeni (1993)*
- *Carbonara (1981)*
- *Mancini (2004)*
- *Pezzi (2005)*

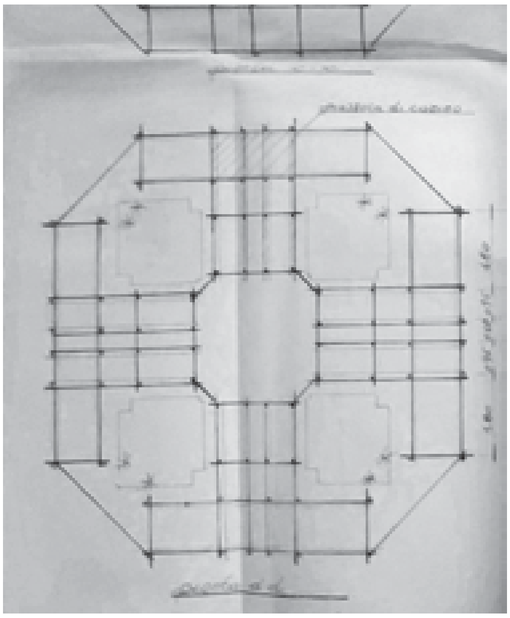
ABBEY OF SANTO SPIRITO A MORRONE

Sulmona (AQ)

Description

The monumental complex, which occupies a large area, stands near Sulmona in Badia. The current layout is composed of a monumental eighteenth-century church and an imposing monastery which is divided into five internal courtyards, three major and two minor. The external portico has cylindrical columns. From the left courtyard, called the courtyard of the Nobles, rectangular in shape, it is possible to pass into the refectory, according to the type of seventeenth-century monastic scheme. The quadrangular structure of the portico embraces the actual church, and is fortified by four corner towers. The church has a Baroque facade, rebuilt after the 1706 earthquake, characterized by two levels with classical architecture, smooth circular columns at the entrance, and blind arches.



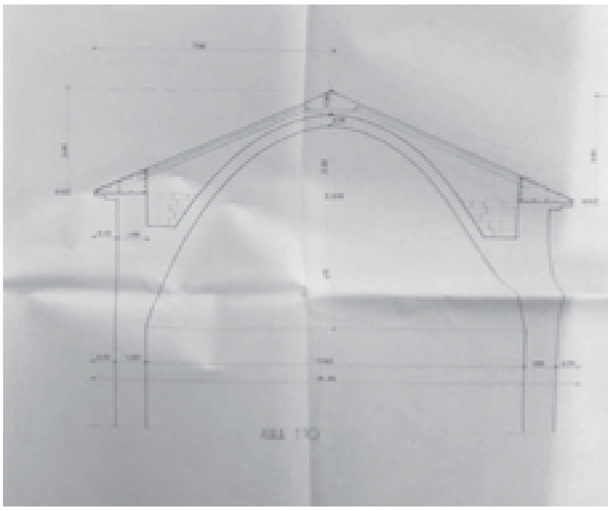


Code: A_1 | 36

Analyzed Restoration Intervention

Period of restoration	**1985-1987**
Client	**Soprintendenza ai Beni Architettonici, Ambientali, Artistici e Storici dell'Abruzzo | Provveditorato alle OO.PP.**
Designer	**B. D'amico, P. Colangeli**
Company	**Consorzio BarFond, L'Aquila/Bari**

The restoration work, completed at the end of the 1980s, involved the remaking of the roof of the entire complex, with the creation of a support curb on the walls and structure in wood and steel. The bell tower was consolidated both by cement-based injections, seams at the openings and reinforcement of the foundation; in the latter case, steel and concrete micropiles were inserted into the ground, in order to ensure uniformity in the support surface.



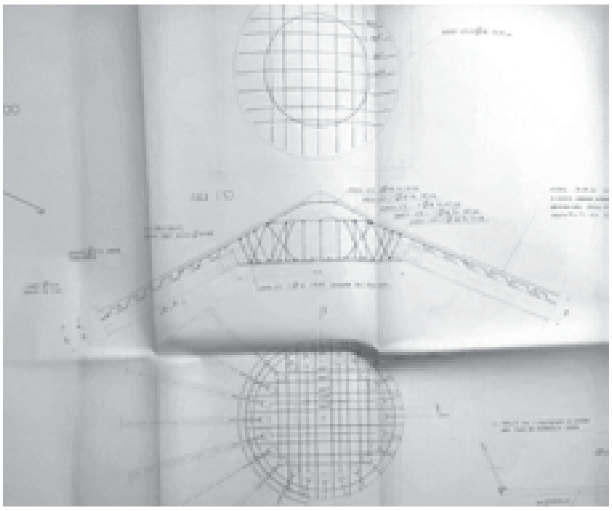


Table of restoration's cataloguing

PHASE 0	**Earthquake**	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	**Foundations**

References

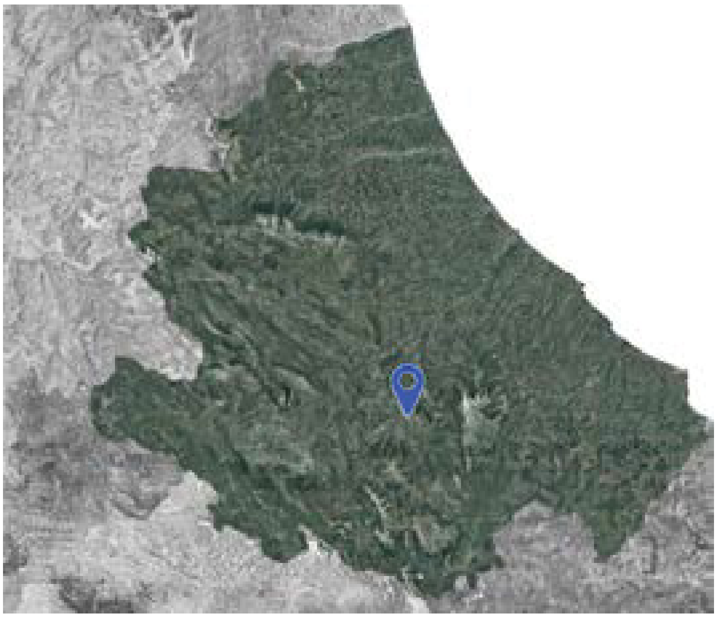
- *Bindi (1889)*
- *Fucinese (1980)*
- *Mancini (1986)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Piccirilli (1888)*
- *Zecca (1858)*
- *AS.BAR*

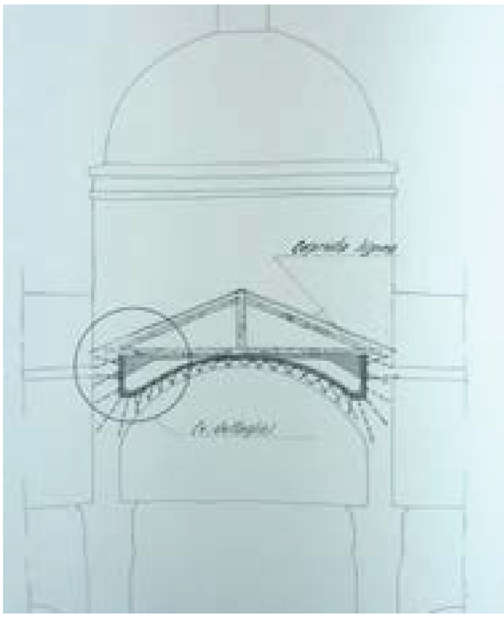
CASA SANTA DELL'ANNUNZIATA

Sulmona (AQ)

Description

The complex of the Santissima Annunziata is the most famous and representative monument of the city of Sulmona. The church, founded in 1320 by the brotherhood of the Compenitents together with the adjoining hospital, does not retain traces of the original construction, both because of the damage suffered in the earthquake of 1456, and because of the architectural transformation that radically changed the structure of the beginning 16th century. In addition, another ruinous seismic event, that of 1706 led to a new, important reconstruction intervention that gave the church a baroque appearance, with an imposing facade with two orders of columns. The interior is divided into three naves and is covered with stuccos.



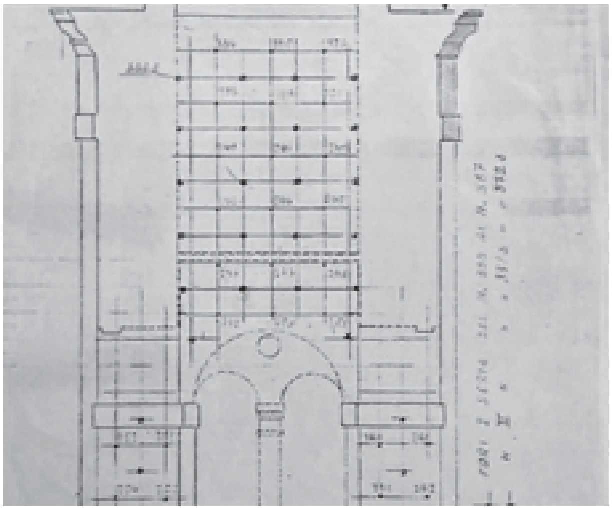


Code: A_1 | 37

Analyzed Restoration Intervention

Period of restoration	**1985-1989**
Client	**Soprintendenza ai Beni Architettonici, Ambientali, Artistici e Storici dell'Abruzzo | Provveditorato alle OO.PP.**
Designer	**G. Migone**
Company	**Consorzio BarFond, L'Aquila/Napoli**

After the previous work of the late Sixty years, with the reinstatement of the spaces and, also the reconstruction of all the roofs in reinforced concrete, this intervention entailed the strengthening of the roofing top beams with transversal reinforced concrete beams, connected to the existing structure by means of steel bars.



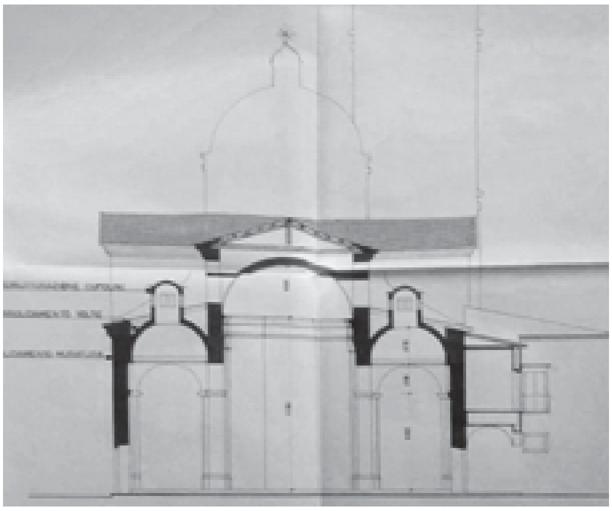


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Abbate (1903)*
- *Badiali (1912)*
- *Carbonara (1981)*
- *Donatelli (2012)*
- *Fucinese (1980)*
- *Mancini (1986, 2004)*
- *Miarelli Mariani (1979)*
- *Moretti (1972)*
- *Pezzi (2005)*
- *Piccirilli (1886, 1888, 1897, 1919)*
- *AS.BAR*

BENINCASA PALACE

Ancona

Description

The palace was built in the 15th century by the will of Dionisio Benincasa, progenitor of one of the oldest and most illustrious families of Ancona owners and merchants. Over time, the building has undergone numerous interventions, maintaining a significant role in city life. Until the 18th century, the ground floor included fifteen arches, three of which functioned as entrances and two as coach houses. In the second half of the 18th century, however, the building underwent another transformation: many elements of the facade disappear ed and the entire building had raised by one floor. Declared monument of national interest, in 1918 the heirs of the Benincasa family decided to sell it, purchasing to INA in 1924. With the purchase, the new owner undertook an immediate restoration, aimed at the original restitution of the rooms.

Code: A_2 | 1

Analyzed Restoration Intervention

Period of restoration	**1926-1931**
Client	**INA | Istituto Nazionale delle Assicurazioni**
Designer	**Guido Cirilli**
Company	**/**

The restoration works provided the reinstatement of the original buildings. The aim of the architect regarded the recreation of the original spaces: he reopened the buffered windows and inserted capitals, hexagonal stone columns. Thanks to the facility of work typical of the material, reinforced concrete had been used for the re-creation of the lunettes.

Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
	War	Reinforced concrete frame's insertion
PHASE 3	**Reinstatement**	Foundations

References

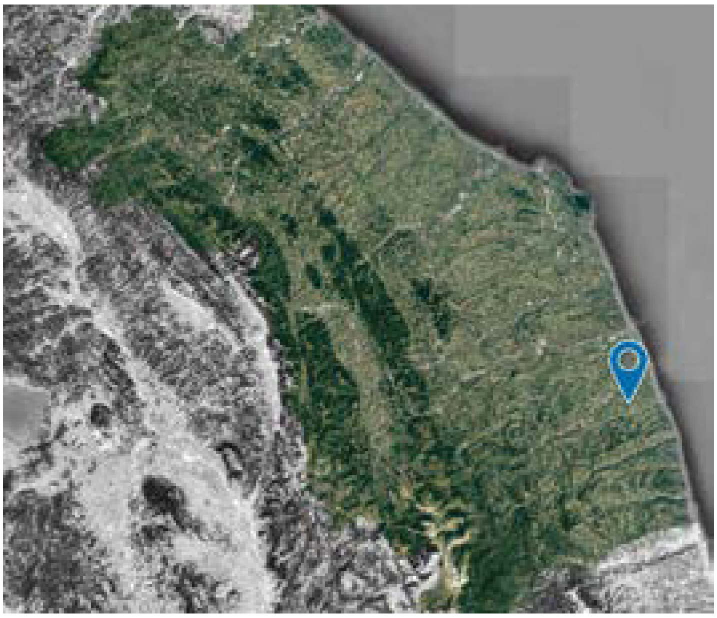
- *Balistreri (2003)*
- *Carbonara (1981)*
- *Il palazzo Benin (1969)*
- *Natalucci (1966)*
- *Sandri (1985)*
- *ICCD, Ferro Candilera*
- *ICCD, Archivio MPI*

CATHEDRAL OF SANTA MARIA ASSUNTA

Fermo (AP)

Description

The Metropolitan Cathedral of Santa Maria Assunta is the main Catholic place of worship in Fermo. The church has a facade in Istrian stone, punctuated by thin pilasters, and a portal with bundles of columns carved in the center, surmounted by a large spire, above which there is the rose window. The left side of the front presents the bell tower, whose insertion has determined the asymmetrical characteristic of the facade. The interior of the cathedral appears in its current conformation to the neoclassical reconstruction made by Cosimo Morellin in the 18th century. The church has three naves separated by round arches and has a double transept. The main nave and the transept are covered with a coffered barrel vault, while the smaller aisles with domes, also coffered. The central nave ends with the deep apse, inside which there is the presbytery.



Code: A_2 |2

Analyzed Restoration Intervention

Period of restoration	**1934-1939**
Client	**Soprintendenza Regia alle Antichità di Ancona**
Designer	/
Company	/

During the archaeological investigations of 1934, it had been discovered the original Paleocristhian church, below the new edifications. Aiming to let continuining the excavations and also the possibility of visit the archaeological area, the ground slab of the new cathedral had been rebuilt in reinforced concrete, as a structural plate above the underground walls.

Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

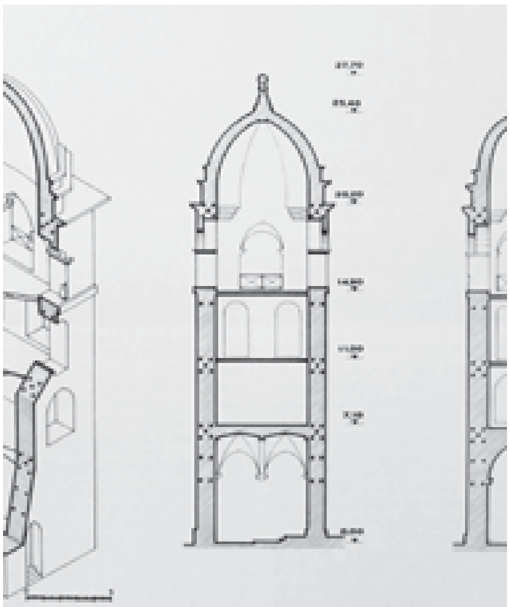
- *Cipolletti (2018)*
- *Livi et al. (2015)*
- *Maranesi (1938)*
- *Tomassini (2016)*
- *ICCD, Gabinetto Fotografico*
- *ICCD, Ferro Candilera*

BELL TOWER OF THE CATHEDRAL OF SAN CIRIACO

Ancona

Description

The tower bell, realized separated from the cathedral of San Ciriaco, had been built in the 14th century, on the rest of a defensive tower. Realized with thick walls in masonry, the upper part of the tower present two orders of windows, with a horizontal crowning, above which it had been realized a dome, supporting the final lantern.

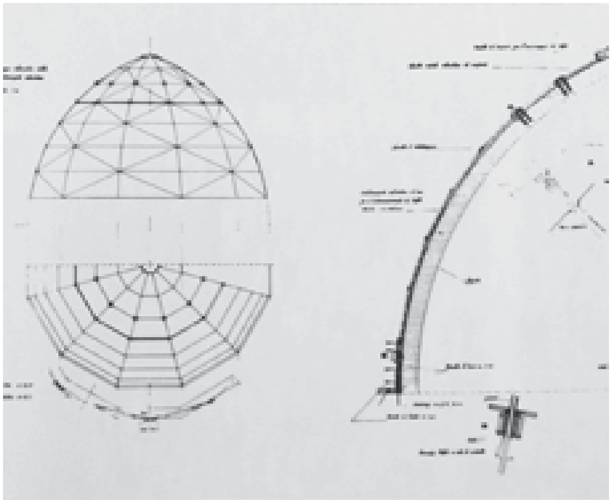


Code: A_2 |3

Analyzed Restoration Intervention

Period of restoration	**1963**
Client	**Soprintendenza ai Beni Architettonici e Ambientali Soprintendente R. Trinci**
Designer	/
Company	**Fondedile S.p.A., Napoli**

The restoration works, pursued previously from the cathedral, interested the structural improvement of the bell tower, which presented several cracks and fissures due to the crushing of the masonries and, probably, to the shakes involved by the bombardments, which hit the cathedral. The intervention consisted in the reinforcement of the masonries with injections and insertions of steel bars; also, involving the stiffening of the different level slabs, the original in wood had been substituted with new ones in reinforced concrete.



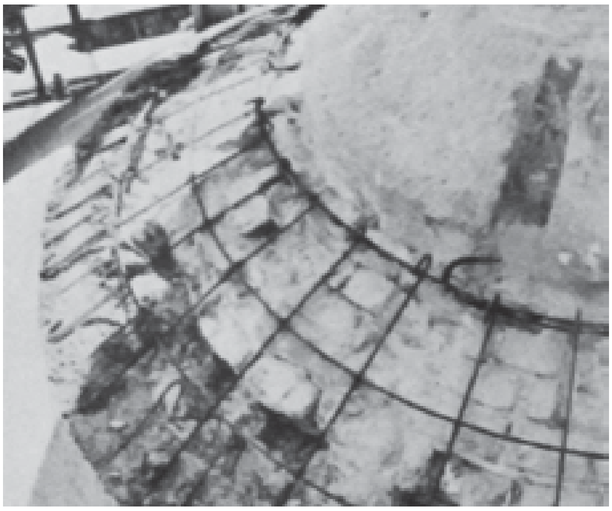


Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Ancona e la sua cattedrale (1999)*
- *Carbonara (1981)*
- *Centanni et al. (1966)*
- *Domenici (1996)*
- *Marinelli (1961)*
- *Ministero Pubblica Istruzione (1950)*
- *Natalucci (1961)*
- *Pirani (1998)*
- *Polichetti (2003)*
- *Polverari (1994)*
- *Restauri nelle Marche (1973)*
- *ICCD, Morpurgo*

ROMAN AMPHITHEATER

Ancona

Description

The Roman amphitheater of Ancona, located between the Guasco and Capuchin hills, constitutesone of the most important Roman architectural works in the city. It is assumed that its construction is begun during the period of Augustus to the late first century B.C., and modified during the time of Trajan (A.D. century - second century A.D.). Its innermost part, with square segments, belonged to a theater from the Greek period. Rediscovered in 1810, in 1930 thanks to the excavations of the Sopreintendenza; other important works had operated with the government funding specifically granted after the 1972 earthquake, involving a new phase for the archaeological studies.

Code: A_2 |4

Analyzed Restoration Intervention

Period of restoration	**1972**
Client	**Soprintendenza ai Beni Archeologici delle Marche**
Designer	**V. Guidi**
Company	**Guidi e Bianchelli, Ancona**

One of the aims of the restoration works pursued by theSoprintendenza interested the liberation of the ancient ruins from the additioned buildings, which insiste in large part of the area. Pursuing this target, the creation of the archaeological area, obtained in part below streets and buildings' embankements, involved the insertion of continuing truss in reinforced concrete, supporting the xisting constructions.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

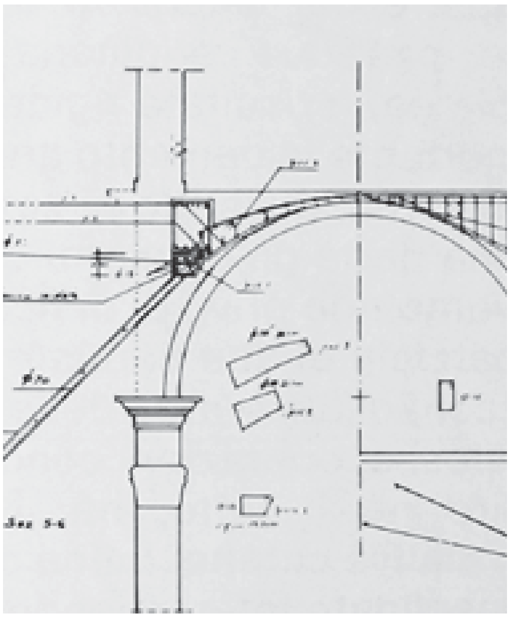
- *Alimenti (2016)*
- *Beer et al. (1978)*
- *Carbonara (1981, 1995)*
- *Comune di Ancona (1974)*
- *Natalucci (1961)*
- *Sebastiani (1996)*
- *ICCD, Gabinetto Fotografico*

PALAZZO DUCALE

Urbino

Description

Ique sum qui si beate nonectibus as di ullaut eum nobist, odipsumet et, consequist, te preium excesto et dus de pos acit ad et rempe vendi dempor a dipis reictem sime volorum harchil intur sitatio nsequi blaceped et odit, esedita turibus magnihi liquiaest fugit harchici omnim vende pelignisquam dolorehendit asperat laborio repratum venis cupit, ut quamusdae veliquatatus ut atibero bea iuntemp erfero ellaut ventia sitas era ipic to conse recatqui conectio. Ut re nusa vit laborep taquias pidest ent, suntiam volorernate eum fuga. Soluptasi ommolup tatemodio. Et labo. Et acea is non ressunt qui omnim acea quiati tes recuptatet debit aut ate dolo to blatum remporem fugitatur, commodiaspe perum estrum ipsa dolo et preium simus ra simporum, nimolentem re core aut quas venis coribus ciissi tenis cus modi untiust, que reperum rero to molum ex eario occat.



Code: A_2 | 5

Analyzed Restoration Intervention

Period of restoration	**1970-1973**
Client	**Soprintendenza ai Beni Architettonici e Ambientali delle Marche**
Designer	**M. L. Polichetti**
Company	**Guidi e Bianchelli, Ancona**

The spiers had been reinforced with a ring beam in reinforced concrete, placed externally at the base, and also an internal reinforced concrete counter-spire, of very small thickness, built inside; the brick elements are anchored on this, set on shelves which, crossing the base of the spire, are hooked to the external top beams. Three different interventions have been adopted for the restoration of the loggias due to the different local situations. In the loggia on the third level a box-like structure was created in reinforced concrete. The structure was set up by means of inclined tie rods hooked to a reinforced concrete beam placed at the top of the building, so as to transfer the load to the statically more efficient wall areas.

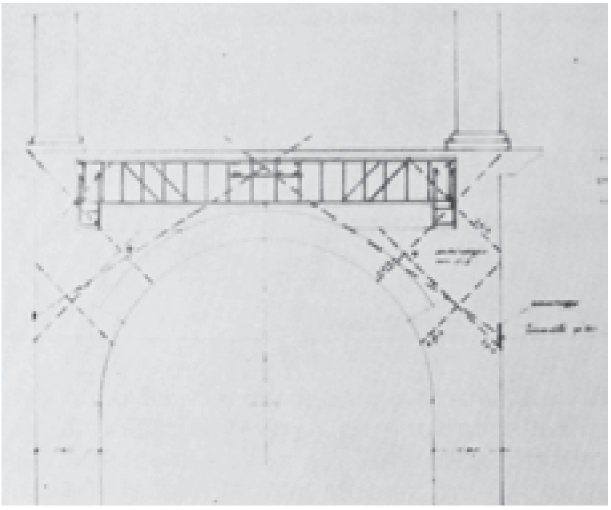


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Carbonara (1981, 1995)*
- *Fondedile SPA (1973)*
- *Ministero (1998)*
- *Polichetti (1985)*
- *Restauri nelle Marche (1973)*
- *Rotondi (1951)*
- *Zampetti (1963)*
- *ICCD, Ferro Candilera*

FERRETTI PALACE

Ancona

Description

Residence of the noble family Ferretti, and seat since 1958 of the National Archaeological Museum of the Marche, the prestigious architectural complex rises in this high part of the city starting from the 15th century assuming the shape of the Renaissance palace: the facade is traditionally attributed to the work of the architect Antonio da San Gallo the Younger, active in Ancona in the 1650s. The interior decoration and the main floor were commissioned by Count Angelo Ferretti to the painter Pellegrino Tibaldi around 1560, already active in the city for the decorative yard of the Loggia dei Mercanti. In 1759 the building underwent a renovation probably designed by Luigi Vanvitelli, with the extension of the facade, the construction of the balcony, the central portal, the grand staircase and the roof terrace, with a portico and loggias above.

Code: A_2 | 6

Analyzed Restoration Intervention

Period of restoration	**1972-1974**
Client	**Soprintendenza ai Beni Architettonici e Ambientali delle Marche**
Designer	**P. Beer**
Company	**Antonio Carli, Piobbico**

The restoration works, involved by the earthquake of 1972. The operating technique chosen for the revitalization of the structures in elevation consists in the introduction, within the main load-bearing walls, of pre-stressed reinforced concrete strands, in bored holes, with a diameter of 5-6cm; the perforations were performed with special equipment developed by the building company.

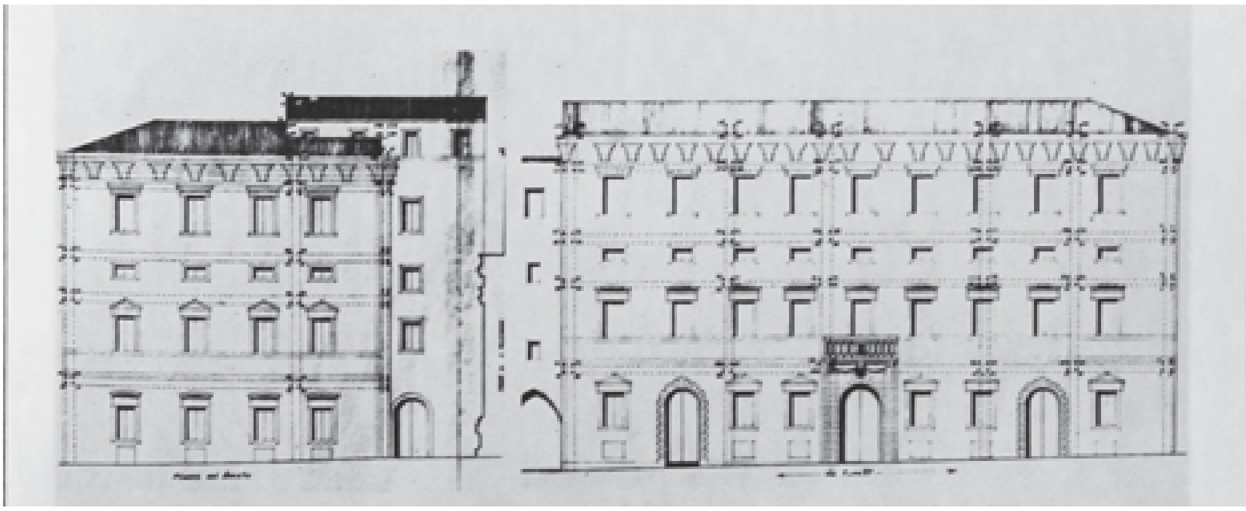


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

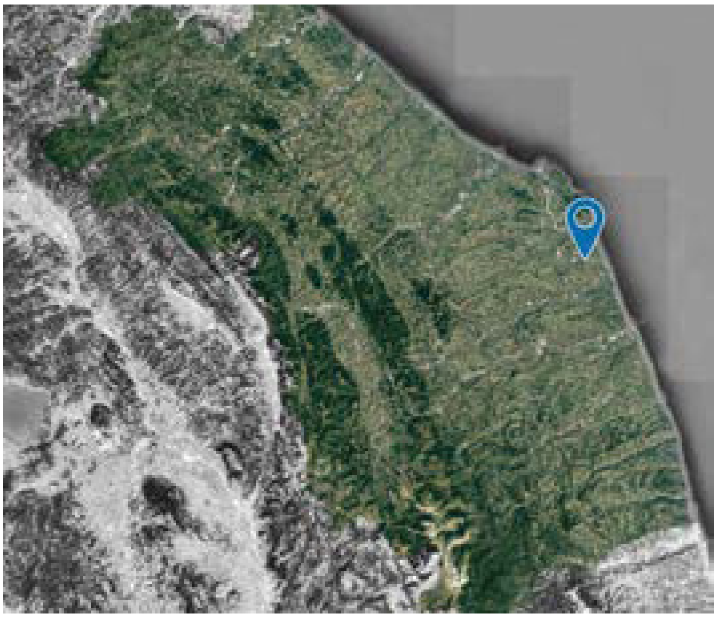
- *Beer (1978)*
- *Carbonara (1981)*
- *Comune di Ancona (1974)*
- *Palazzo Ferretti (2014)*
- *ICCD, Ferro Candilera*

TOWER BELL OF THE BASILICA DELLA SANTA CASA

Loreto (AN)

Description

The tower bell rises on the left side of the Basilica, rising 75.60 m high. It was built between 1750 and 1754, based on a design by Luigi Vanvitelli. Built in bricks, with white Istrian stone finishes, it is composed of four levels, with upper lantern and pinnacle. The two basics, incorporated in the Apostolic Palace, are square in plan; the third has an octagonal plan, the fourth with a circular plan and the fifth consists of the balustrade with the soaring baroque bulb pinnacle.



Code: A_2 | 7

Analyzed Restoration Intervention

Period of restoration	**1977**
Client	**Soprintendenza ai Beni Architettonici e Ambientali delle Marche**
Designer	**P. Beer**
Company	**/**

Due to the deterioration caused by the weather and to deal with the effects of wind and earthquake, the restoration affected the cusp and its basic pinnacles. After coring performed from above along the axis of the pinnacle, the various pieces were dismantled and reassembled with threaded brass connecting bars. Subsequently, a strand with sheath was inserted in the central hollow, which after the injection of cement and resins into the hole, was pulled. The traction was calculated as a function of the horizontal thrust to which the pinnacle may be subjected to wind and earthquake, taking into account the compressive strength of the stone, thermal variations, relaxation, shrinkage and friction.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

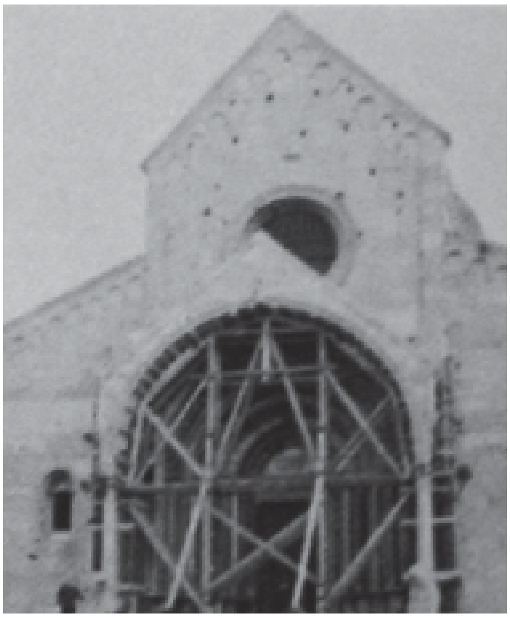
- *Beer (1978)*
- *Carbonara (1981)*
- *Grimaldi (1975)*
- *Santarelli (2003)*
- *ICCD, Gabinetto Fotografico*

CATHEDRAL OF SAN CIRIACO

Ancona

Description

The cathedral represents a high example of Romanesque art mixed with Byzantine and Gothic elements; it constitutes one of the most important examples of this style in Italy. The façade, divided into three parts, is preceded by a wide staircase, above which rises the thirteenth-century Romanesque splayed prothyrum, formed by a full arch supported by four columns. The interior has a Greek cross with three naves. The columns are reused Roman and end on capitals, some of which are Byzantine. At the center of the cross is the slender ribbed dodecagonal dome, with pendentives supported by Byzantine figures. The dome rests on polystyle cruciform pillars; the flying buttresses that connect it to the external walls have the peculiar characteristic of being placed inside and not outside the building.



Code: A_2 |8

Analyzed Restoration Intervention

Period of restoration	**1973-1979**
Client	**Soprintendenza ai Beni Architettonici e Ambientali delle Marche** **Soprintendente R. Trinci | M.L. Polichetti**
Designer	/
Company	**Guidi e Bianchetti, Ancona**

According to static analysis, the church presented serious and worrying instabilities: injuries on the walls of the naves near the arches supporting the dome, on the masonry above the arches and at the base of the columns. Reinforced concrete has been used both for the foundation structures, reinforcing the plinths of the columns with linking beams, and for the elevated ones, with the insertion of top beams in reinforced concrete on the thrusts of the main nave. Also the dome had been intereste by the application of reinforced concrete, in its base ring beam.

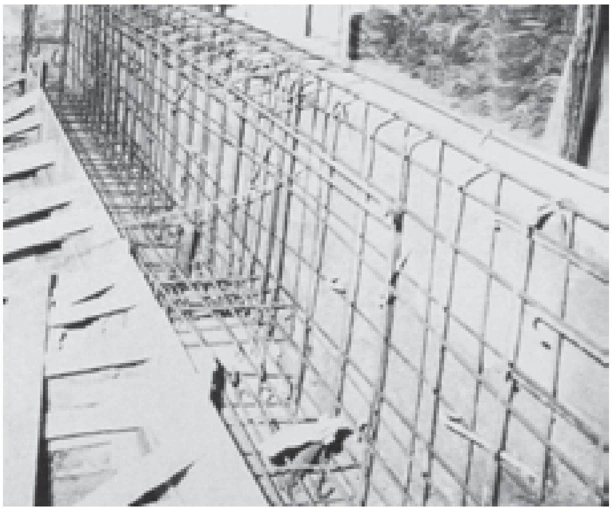


Table of restoration's cataloguing

PHASE 0	**Earthquake**	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	**War**	Reinforced concrete frame's insertion
	Reinstatement	**Foundations**

References

- *Ancona e la sua cattedrale (1999)*
- *Carbonara (1981)*
- *Centanni et al. (1966)*
- *Domenici (1996)*
- *Marinelli (1961)*
- *Ministero Pubblica Istruzione (1950)*
- *Natalucci (1961)*
- *Pirani (1998)*
- *Polichetti (2003)*
- *Polverari (1994)*
- *Restauri nelle Marche (1973)*
- *ICCD, Morpurgo*

ROSSINI THEATRE

Pesaro (PU)

Description

Built in 1637 as the Teatro del Sole, it was rebuilt on its original site in 1818 taking the name of Teatro Nuovo. The Rossini Theater, which has taken its current name in honor of the composer since 1854, has a capacity of 860 seats, with an auditorium designed with the classic horseshoe shape with four tiers of boxes plus the gallery. The earthquake of October 30th 1930, a 6.0 magnitude earthquake that hit the provinces of Pesaro and Ancona, required about four years of renovation. The theater reopened in August 1934. In 1966, the formation of cracks along some walls and the deterioration of many of the wooden parts led to its closure which then continued for fourteen years.

Code: A_2 | 9

Analyzed Restoration Intervention

Period of restoration	**1964-1980**
Client	**Comune di Pesaro**
Designer	**L. Papi**
Company	**Fondedile S.p.A., Napoli**

The restoration pursued aimed to redifine the structures of the stage, which were interested by the appearence of cracks and fissures immediatly after the previous intervention. The works provided for the insertion of auxiliar elements in reinforced concrete, T shape, in a way to support the masonries and the other elements of the stage. Also, the foundations had been improved, with the realization of sub-foundations elements, and reinforces through the insertion of poles.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Brancati (1985)*
- *Carbonara (1981)*
- *Fondedile SPA (1973)*
- *Zeitz (2005)*
- *ICCD, Ferro Candilera*

BASILICA OF SAN PIETRO

Perugia

Description

The monument, founded at the end of the 10th century by San Pietro Vincioli, preserves the original structure in the passages of the naves: while the original apse ending was replaced in the 14th century by a large transept concluded by a very elongated polygonal apse. The entrance to the monastery introduces a monumental facade with three arches, designed around 1614. The entrance to the church is on the left side of the cloister. Remains of the facade of the ancient basilica can be seen to the right and left of the 15th century portal, with a portico that includes some frescoes from the 14th and 15th centuries. Transept, choir and side aisles are vaulted, the central nave with a gilded and painted ceiling. The polygonal bell tower, to the right of the portal, was rebuilt in 1463-68 with Florentine Gothic lines, based on a design by Bernardo Rossellino.

Code: A_3 | 1

Analyzed Restoration Intervention

Period of restoration	**1959-1962**
Client	**Soprintendenza ai Monumenti e Gallerie di Perugia** **Soprintendente G. Martelli**
Designer	**R. Pardi, S. Mastrodicasa**
Company	/

The performed intervention had been focused on the structural reinforcemnt of the transpet, which presented failure displacements, and on the roof system of the entire church, in state of decay. In particular, the vaults of the transpet had been emptied, and there were inserted new top beams in reinforced concrete, aiming to support the new structure of the roof, realized wth steel trusses and sloped slab in reinforced concrete and hollow bricks. Also the roofs of the naves had been interested by the same approach.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Attività soprintendenze (1965)*
- *Carbonara (1981, 1995)*
- *Farnedi (2011)*
- *Gurrieri (1964)*
- *Manari (1864)*
- *Montanari (1996)*
- *Relations from restoration works by Maura Giacobbe Borelli (2014)*
- *ICCD, Ferro Candilera*

CATHEDRAL OF SAN GIOVENALE

Narni (TR)

Description

Dedicated to its first bishop San Giovenale, the construction of the church began in 1047, adjacent to the city walls and after an interruption due to the flood of 1053, was completed and consecrated in 1145. The main façade of the 11th-12th century is preceded by a fifteenth-century portico which reveals the three portals. The portico has the right side closed by a chapel where the baptismal font from 1506 is located. Above the portico, the original curtain retains three arched single lancet windows. The basilica plan with an Latin cross placed has three naves with a large polygonal apse at the end. The transept is separated from the longitudinal space through a diaphragm created by three arches. The presbytery is raised with the crypt below. The roof is with cross vaults, while the apse has a vaulted ceiling with ribs.

Code: A_3 |2

Analyzed Restoration Intervention

Period of restoration	**1961-1964**
Client	**Soprintendenza ai Monumenti e Gallerie di Perugia**
Designer	**Ufficio del Genio Civile di Terni | A. Ugolinelli, G. Martelli**
Company	**Pelucca Samuele, Pinchi Libero**

The consolidation works consisted in the reconstruction roofs in reinforced concrete structures and hollow-bricks over the 15th century vaults of the naves, naturally preserved despite the fact that their pitch does not agree with the columns, nor also with the original windows, many of which - indeed - are intersected by them. The works interested in the reinforcement of the walls above the arches, in the restoration of the facade, in the partial remaking of the floor.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Attività soprintendenze (1965)*
- *Franzoni et al. (2007)*
- *Martelli (1965)*
- *Carbonara (1981)*
- *D'Andrea (2010)*
- *Perissinotto (1998)*
- *ICCD, Gabinetto Fotografico*

LAZZARETTO

Castel Rigone (Passignano sul Trasimeno Municipality | PG)

Description

Sanctuary built around 1494 on a design perhaps by Bramante, but most likely the work of one of his pupils, Rocco da Vicenza. Located outside the ancient walls, the lazaretto consists of a block element inserted among the other architecturally very modest houses, made mostly of exposed stone masonry. The main façade, which presents itself with the portico on the ground floor and the loggia on the upper floor, looks onto the public road. The portico on the ground floor is made up of square pillars in blocks of yellow sandstone, the corners of which are rounded at approximately 45 ° topped by brick arches; the capital is made with a simple sandstone nut. The loggia on the upper floor, on the other side, is of a red color, as the columns and bricks. The roof of the whole building is made of wood.

Code: A_3 |3

Analyzed Restoration Intervention

Period of restoration	**1974**
Client	**Soprintendenza ai Monumenti e Gallerie di Perugia**
Designter	**D. Valentino**
Company	**/**

The restoration project aimed to redifine the spaces of the building, for the use as museum (some spaces) and spaces for volunterring associations. The intervention provided the reinforcement of walls with cement injections, and the realization of the foundation of a dismailed area with a reinforced concrete plate, the substitution of some parts of the roof with reinforced concrete prestressed beams and slabs.

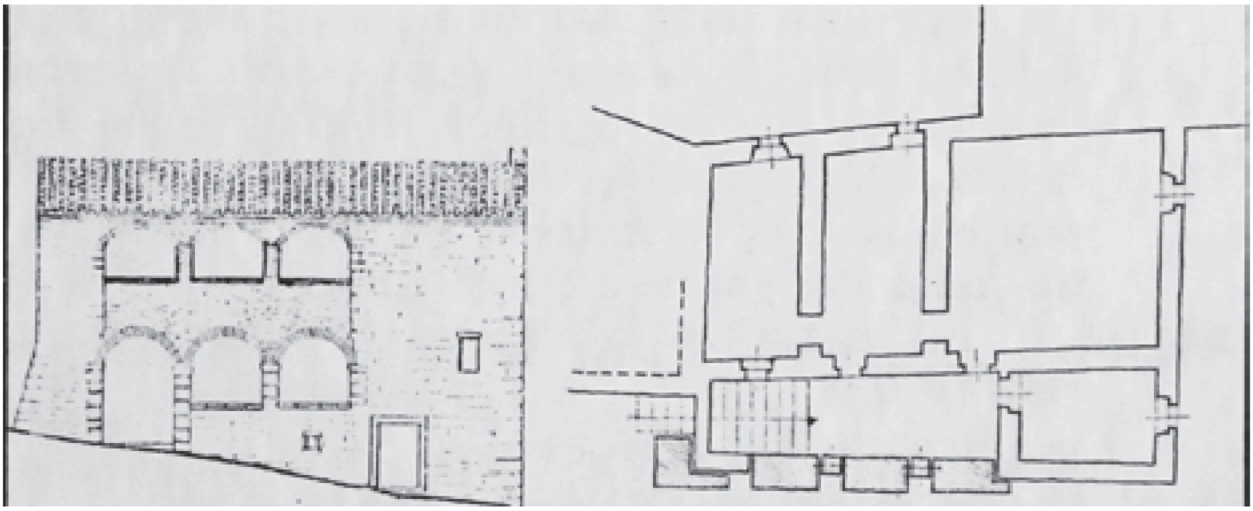


Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	**Foundations**

References

- *Briganti et al. (1910)*
- *Carbonara (1981)*
- *Cavicchi (1992)*
- *Valentino (1975)*
- *ICCD, Gabinetto Fotografico*

BUILDING IN VIA DELL'ASSALTO

Spoleto (PG)


Description

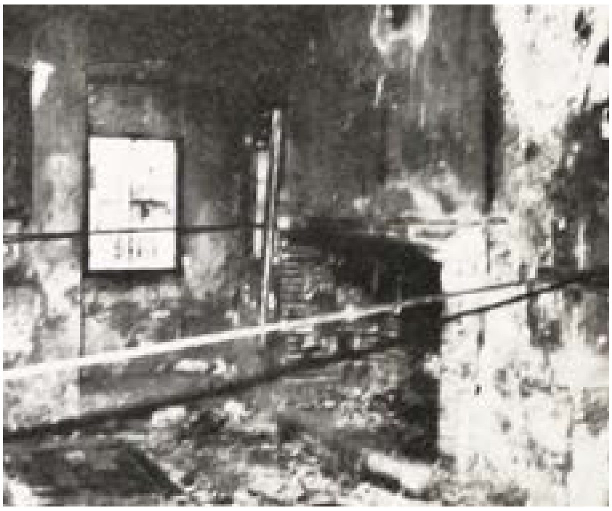
The building, located in the city center of Spoleto between the cathedral and the cyclopic walls, close also to the theatre Caio Melisso, comprises three floors. Its construction began about in the 15th century. In spite of the modifications of the 17th and 18th century, the building represents a precious proof of the local society history, with the alternation of the family owners. The environmental value of the building, cause of its historical aspects and development, involved serious works of restorations, pursued among the last century by the Soprintendenza, intending to recover the collapsed area and the decaying structures of the interior.


Code: A_3 |4

Analyzed Restoration Intervention

Period of restoration	**1974-1975**
Client	**Soprintendenza ai Monumenti e Gallerie di Perugia**
Designer	**G. Tosti, G. Caravaggi**
Company	**CU.MAR. Spoleto**

The work interested large part of the building, cause the spread decaying conditions of the structures. In particular, reinforced concrete elements had been positioned supporting all the structures: in the foundations, with the insertion of a foundation beam, and in the whole walls, inserting columns and top beams, able to support also the new slab, realized in reinforced concrete and hollow bricks. In this way, the restoration aimed to eliminate the structural role of the masonry walls, insted of the new elements. The roof of the building had been completelly demolished and rebuilt.



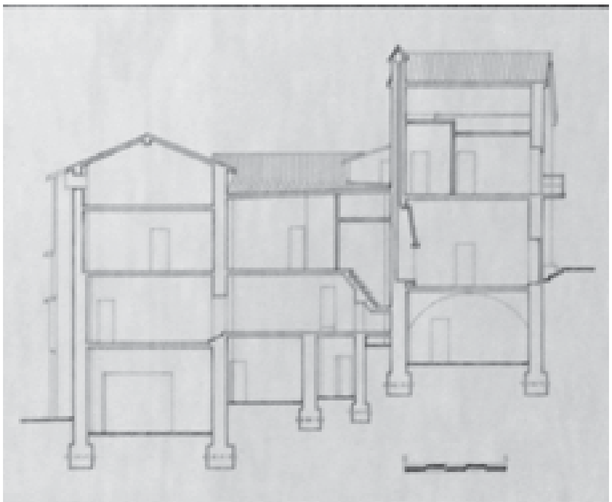


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	**Reinforced concrete frame's insertion**
	Reinstatement	**Foundations**

References

- *Carbonara (1981)*
- *Tosti (1976)*

CATHEDRAL OF SANTA MARIA ASSUNTA

Spoleto (PG)

Description

Spoleto Cathedral is the principal church of the Umbrian city of Spoleto. The church is essentially an example of Romanesque architecture, with a nave and two side-aisles crossed by a transept, although subsequently modified. It was built from the second half of the 12th century after the city had been devastated by Frederick Barbarossa's troops, over an area where there had previously stood an earlier cathedral. A notable external porch and the belfry were added in the 15th and 16th century respectively. The façade is divided into three bands. The lower one has a fine architraved door with sculpted door-postsThe upper bands are separated by rose windows and ogival arches. The interior was significantly modified in the 17th–18th centuries, though it has kept the original Cosmatesque floor of the central nave remains.

Code: A_3 | 5

Analyzed Restoration Intervention

Period of restoration	**1972-1976**
Client	**Soprintendenza ai Monumenti e Gallerie di Perugia**
Designer	**G. Martelli, R. Pardi**
Company	**Loris Cittadoni**

The restoriation intervention aimed to redifine the roofing system of the building, which, after the restoration work pursued in the fities by the Genio Civile, was still in bad conditions. In this case, the roof system had completelly intereste; reinforced concrete top beams had positioned above the walls, while the structure of the roof had been realized, in some parts, with steel trusses.

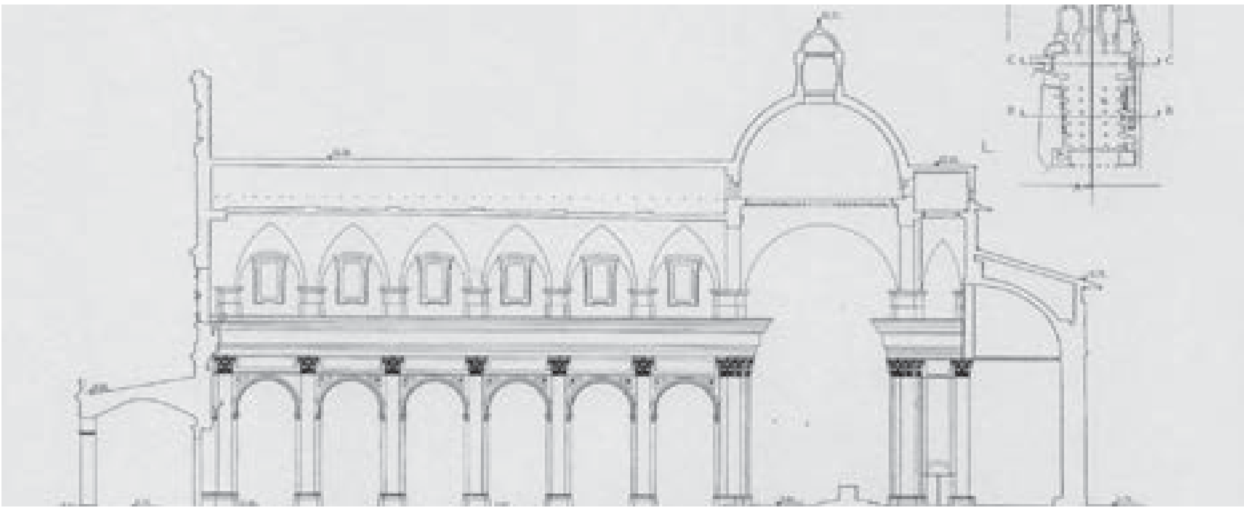


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Benazzi et al. (2002)*
- *Carbonara (1981)*
- *Fontana (1848)*
- *Il duomo di Spoleto (1925)*
- *Sordini (1908)*
- *Toscano (1969)*

ICCD, Ferro Candilera

CIVIC AND ARCHAEOLOGICAL MUSEUM

Amelia (TR)

Description

Former Boccarini College, this complex is on the site of a palace that belonged to the Boccarini family, which was documented in Amelia from the late 13th century. It was ceded to the papal governor in 1410. The palace was subsequently adapted as the convento of San Francesco. It enjoyed particular prestige in the 16th century, when Brother Egidio Delfini of Amelia was Minster General of the Franciscans. The cloister dates to this period. The complex is next heard of after the unification of Italy in 1860, when it was used as a college (the “Convitto Boccarini”). It passed to the Salesian Fathers in 1932.

Code: A_3 | 6

Analyzed Restoration Intervention

Period of restoration	**1975-1982**
Client	**Comune di Amelia (TR)**
Designer	**E. Corvi, C. Di Pascasio**
Company	/

Aiming ot renovate the entire building, cause the spread decay, the restoration interested the structural reinforcemt of the wall, with the insertion of steel columns, linked at the top level thanks to reinforced concrete beams, able to support also the new roof. In some part of the buildings, the new roof are made by trusses in prestressed reinforced concrete, connected to the existing walls with steel bars.

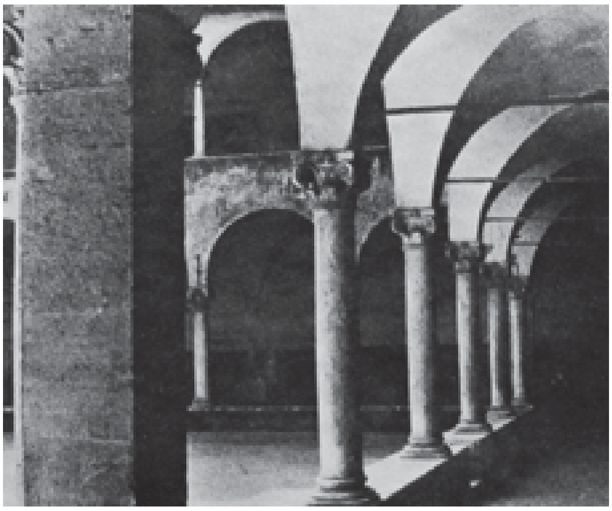


Table of restoration's cataloguing

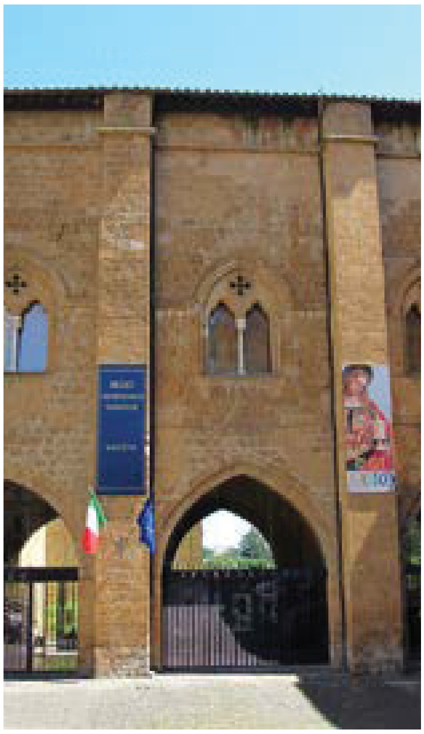
PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Apa (2015)*
- *Arca Petrucci et al. (2006)*
- *Carbonara (1981)*
- *Cerasi (2005, 2006)*
- *Corvi (1978)*
- *Umbria (2003)*

PALAZZO PAPALE (SOLIANO)

Orvieto (TR)



Description

The complex of Palazzo Papale in Orvieto comprises two different buildings, close to the bishop palace, made in two periods. The first building, the Palace of Urbano IV is made of two large rooms and a perpendicular smaller room, covere with barrel vault at the ground floor; the second level with a wood ceiling with transversal arches. The broadening of the palace, constituing the palace of Martino IV, involved the construction of the loggia and two other large rectangular rooms in the other directions: the ground level presents six cross vaults with two central pillars, while the second floor had two big arches, collapsed during time. The building suffered lot of modification both in the interior than also in the exterior, causing the difficulty of reading of the original openings and building's size.

Code: A_3 |7

Analyzed Restoration Intervention

Period of restoration	**1958-1983**
Client	**Soprintendenza Monumenti e Gallerie dell'Umbria**
Designer	**R. Pardi, D. Valentino, B. Terzetti, G. Tosti**
Company	**Giovanni Nelli | Marino Mortini, Orvieto**

The restoration works, which took more than twenty years, aimed to remove the additions, reinstating the original spaces of the medieval age, giving back the openings of the fronts. Also, the intervention provided the structural reinforcement, due to the failures and crashing of the columns of the ground floor, the collapse of the great arch of the palace of Martino IV. In this case, the reinforced concrete approach had been interested the recretion of the slabs of the two floors, realized with new plates, and, expecially, the recreation of the collapsed arch.

Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

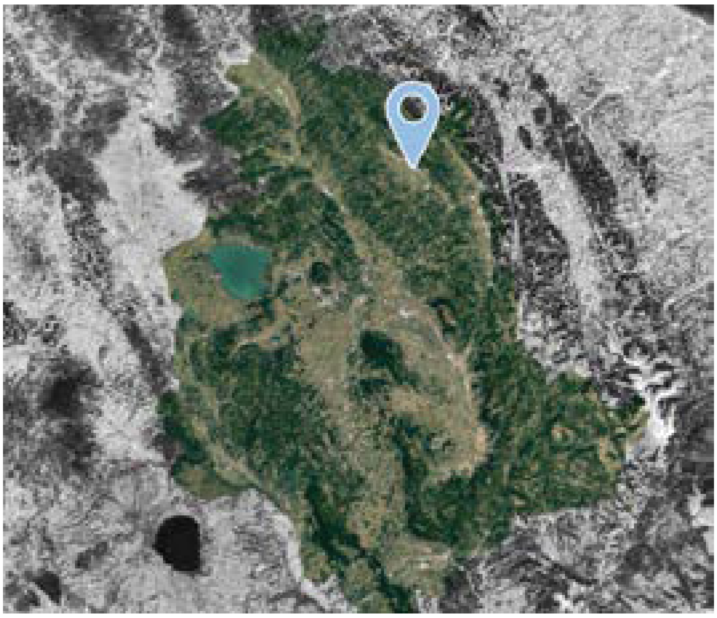
- *Attività soprintendenze (1965)*
- *Bonelli (1939)*
- *Carbonara (1981, 1995)*
- *Fumi (1896)*
- *Malentacchi (1994)*
- *Pardi (1971)*
- *Perali (1919)*
- *Valentino (1975)*
- *ICCD, Raffaelli, Armoni e Moretti*

THEATRE OF THE MUNICIPALITY

Gubbio (PG)

Description

The Municipal Theater of Gubbio began to be built starting from 1713 with more modest dimensions than the current ones. An academy specifically made up of noble Eugubines promotes and finances the initiative. Internally the building was designed and decorated around 1737 by the architect Maurizio Lottici and the painter Giovanni Mattioli, both from Parma, with the supervision of the abbot Bartolomeo Benveduti. The theater was inaugurated in the carnival of 1738, since the beginning it has been used for performances, concerts, jokes. The structural situation became critical in 1822. The theater in 1961 was declared unfit for use due to precarious static conditions. The restoration works began in 1975 and ended in February 1985, with the inauguration of the restored building on the following 24 March.



Code: A_3 |8

Analyzed Restoration Intervention

Period of restoration	**1975-1985**
Client	**Soprintendenza per i Beni Architettonici e Ambientali dell'Umbria**
Designer	**G. Tosti**
Company	**Monacelli, Gubbio**

With the complete failure of some structures, the intervention aimed to recreate the new structure of the building: the lack of resistance of the original structure in wood and bearing brick walls had been completelly changed with new wall realized in reinforced concrete, substituting the brick ones, with also new slabs in reinforced concrete. With this application, the original structure, made in wood, had completelly released from the structural functions. In the intervention, also, the damaged vaults had been reinforced with steel structure positioned in the extrados.

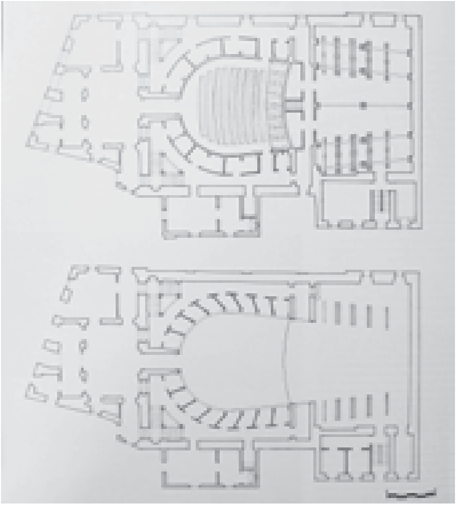


Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Briganti et al. (1910)*
- *Carbonara (1981)*
- *Cece et al. (2000)*
- *Teatro comunale (1997)*

LOGGIA DEI PAPI

Viterbo

Description

Located inside the palace of the popes, the loggia, called "delle Benedizioni", opens on the side of the square with a game of arches supported by slender columns. In the center there are three round arches and on the sides two half arches, ending at the top with the walls respectively of the Palace (left) and the Curia (right). Three more are intertwined with these, so the effect is that of seven pointed arch openings resting on six columns, with three-lobed arches. A trabeation runs along the upper part of the arches, the lower band of which is enriched with square tiles bearing city, imperial and papal symbols. The flat part of the loggia is made up of a balcony in the center of which there is a fountain from the 15th century. The loggia is supported by two lowered arches and an enormous octagonal section pillar.

Code: A_4 | 1

Analyzed Restoration Intervention

Period of restoration	**1902-1906**
Client	**Ministero della Pubblica Istruzione**
Designer	**P. Guidi**
Company	**Giovanni Nottola, Viterbo | G. Gabellini, Roma**

The restoration of the Loggia dei Papi constitutes one of the first restoration intervention realized with the insertion of elements in reinforced concrete. The Loggia, with the arches closed due to static problems, found in the development and use of reinforced concrete the means for the restitution of the original aspects. The work provided the deassemblation of the existing covering stone elements, the application of the beam, and the reposition in place, thanks to the previous cataloguing.

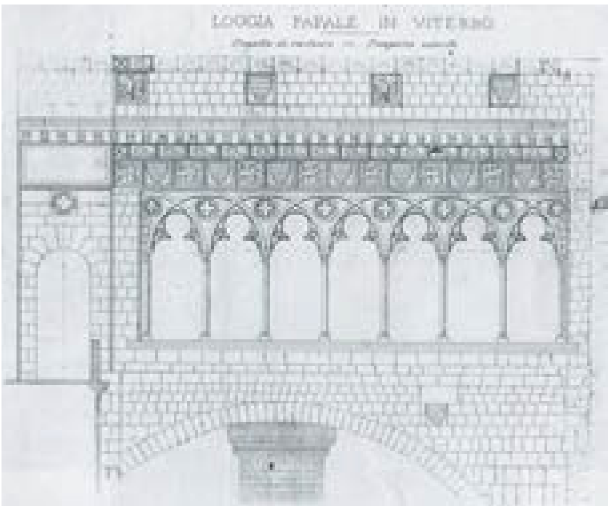


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Carbonara (1981)*
- *Della Costa et al. (2005)*
- *Gavini (1923)*
- *Guidi (1911, 1932)*
- *Pezzi (2005)*
- *Pinzi (1889)*
- *Radke (1996)*
- *Scriattoli (1920)*
- *Valtieri (2005)*
- *Varagnoli (2000)*
- *ICCD, Ferro Candilera*

CHURCH OF SAN PIETRO

Tuscania (VT) | first intervention

Description

The church of San Pietro, founded between the 8th and the 9th century, represents one of the most important monuments of Tuscia. The façade, advanced in the central body, presents as main elements the main portal, the rose window surrounded by a multitude of decorative elements and the side entrances. The main gate is the work of a Roman marble worker from the Cosmatesque school. The interior of the church is divided into three naves: the central one, in which a cosmatesque floor with geometric decorations stands out, is separated from the others by a low wall. In the right nave there is a ciborium dating back to the 13th century and the main entrance to the crypt. In the left aisle the secondary entrance to the crypt surmounted by a frescoed niche. The raised presbytery houses a ciborium from 1093, a Romanesque ambon.

Code: A_4 | 2

Analyzed Restoration Intervention

Period of restoration	**1950s**
Client	**Soprintendenza ai Monumenti di Roma** **Soprintendente C. Ceschi**
Designer	**F. Sanguinetti**
Company	**/**

The first restoration intervention had been pursued aiming to recover the roof system, in state of decay. The attempt of the elimination of overturning stresses from the roof had been reached with the stiffening of the foundation with cement injection and, in particular, the insertion of 12 columns in reinforced concrete inside the masonry, in correspondence of the external walls, linked with top beams in reinforced concrete. Also the walls of the main nave had been integrated with reinforced concrete top beams, aiming to link all the structural addtioned elements.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
	War	Reinforced concrete frame's insertion
PHASE 3	Reinstatement	Foundations

References

- *Carbonara (1981, 1995)*
- *Ceschi (1959)*
- *Demetrescu (1997)*
- *Il romanico. Architettura... (1996)*
- *Raspi Serra (1971, 1972)*
- *Staccini (2005)*
- *ASD. Corriere*
- *ICCD, Gabinetto Fotografico*

TEMPLE OF SANTA MARIA DEL SANGUE

Velletri (Roma)

Description

The origin of the church, dedicated to Maria SS.ma del Sangue, is due, according to tradition, to a miraculous event that took place on June 6th 1516, when an image of the Madonna teared blood. The people wanted to build a temple to venerate the image and so in 1524 the construction of the church began, later consecrated in 1579. The temple is octagonal in shape with pillars and cornices of peperino, with eight round windows; it was restored in 1954 by Giuseppe Zander who modified the roof making it start above the circular windows. Inside the temple there were three altars, in one of which is the miraculated image.

Code: A_4 | 3

Analyzed Restoration Intervention

Period of restoration	**1954-1955**
Client	**Associazione delle Madri e Vedove di Guerra**
Designer	**Ufficio del Genio Civile di Roma | G. Zander**
Company	/

The restoration works took place according to the damaged which the church suffered with the explosions of a bomb from the Second World War. The Genio Civile proposed the restoration project, inserting a sort of reinforced concrete cage around the dome, recreating the original aspect which had been modified during times.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

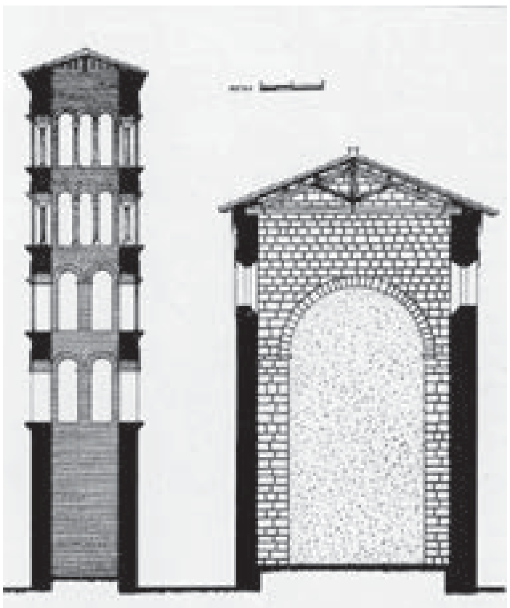
- *Carbonara (1981, 1995)*
- *Gabrielli (1923)*
- *Mammuccari (2002)*
- *Wittkover (1954)*
- *ICCD, Gabinetto Fotografico*

DIOCESAN AND SACRED ART MUSEUM

Orte (VT)

Description

The Sacred Art Museum of Orte was inaugurated in 1967 on the initiative of Bishop Roberto Massimiliani, who intended to collect, preserve and exhibit the most precious sacred works of art in the former church of San Silvestro in Orte and its diocese. The museum, in addition to being the first diocesan museum built in Lazio, has the advantage of being housed in the oldest architecture of the city: the church of San Silvestro, founded in the mid 11th century, had been closed to worship from the early 20th century; the church had been restored in its primitive Romanesque forms in the Sixties to house the diocesan art collection. The single-nave church, built almost entirely of blocks of tuff, has two large walled arches on the south wall that originally connected it to a lateral nave in which the base of the fine bell tower insisted today isolated next to the religious building.



Code: A_4 | 4

Analyzed Restoration Intervention

Period of restoration	**1955**
Client	**Soprintendenza ai Monumenti per il Lazio**
Designer	**F. Sanguinetti**
Company	**/**

Aiming to modify the purpose of the building, from the abandoned church to the diocesan museum, the building had been interested by the insertion of elements in reinforced concrete, such as the top beams in supporting of the roof.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Anselmi et al. (2013)*
- *Carbonara (1981, 1995)*
- *Mortari (1967)*
- *Sanguinetti (1961)*
- *ICCD, Archivio MPI*

CHURCH OF SAN PIETRO

Tuscania (VT) | second intervention

Description

The church of San Pietro, founded between the 8th and the 9th century, represents one of the most important monuments of Tuscia. The façade, advanced in the central body, presents as main elements the main portal, the rose window surrounded by a multitude of decorative elements and the side entrances. The main gate is the work of a Roman marble worker from the Cosmatesque school. The interior of the church is divided into three naves: the central one, in which a cosmatesque floor with geometric decorations stands out, is separated from the others by a low wall. In the right nave there is a ciborium dating back to the 13th century and the main entrance to the crypt. In the left aisle the secondary entrance to the crypt surmounted by a frescoed niche. The raised presbytery houses a ciborium from 1093, a Romanesque ambon.

Code: A_4 | 5

Analyzed Restoration Intervention

Period of restoration	**1971-1973**
Client	**Soprintendenza ai Beni Architettonici e Ambientali del Lazio Soprintendente G. Di Geso**
Designer	**G. Di Geso, G. Ruggieri**
Company	**Antonio Gentili, Bagnoregio**

The second intervention followed the earthquake of 1971, which involved the collapse of the vault of the aisle and the rose window. All the walls had been injected with cement mortar. The feassured vaults had been reinforced with extrados vaults in reinforced concrete; the aisle's vault had been reconstructed directly in reinforced concrete, connected to top beams.

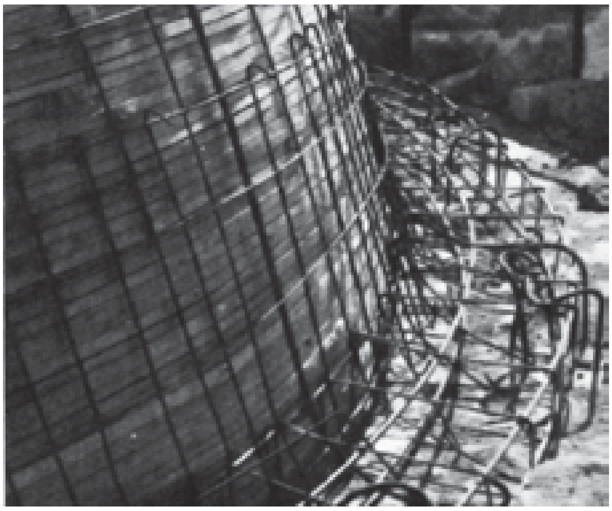


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Carbonara (1981, 1995)*
- *Ceschi (1959)*
- *Demetrescu (1997)*
- *Il romanico. Architettura... (1996)*
- *Raspi Serra (1971, 1972)*
- *Staccini (2005)*
- *ASD. Corriere*
- *ICCD, Gabinetto Fotografico*

CHURCH OF SANTA MARIA DELLA ROSA

Tuscania (VT)

Description

The church was built between the 13th and 14th centuries and most likely served as a cathedral during the 1400s. The building has a facade that opens into three portals, the central one of which is adorned with twisted columns, above which there is a rose window enriched with arches. On the right, instead, there is the bell tower, which began as a square tower and made into a sail, which opens into a plane of Roman mullioned windows. The interior is divided into three naves.

The church had been interested by the earthquake of 1971, with several damages due to the overturning behaviour of the facade and cracks on the vaults.

Code: A_4 | 6

Analyzed Restoration Intervention

Period of restoration	**1971-1974**
Client	**Soprintendenza per i Beni Architettonici e Ambientali del Lazio**
Designer	**G. Di Geso, G. Ruggieri**
Company	**Rinaldi Vittorio Consalvi, Roma | Giorgio Viero, Roma**

With the damages involved by the earthquake, the church had been interested by reinforcement interventions. In particular, the Gothic Chapel, interested by several damages, had been reinforced with steel bars inserted in the perimetral walls and with the creation of an extrados vault in reinforced concrete, linked to the existing through transversal steel bars. The facade had been interested by the insertion of a foudation slab in reinforced concrete, linked to the whole structure through connections with the basement beams of the church.

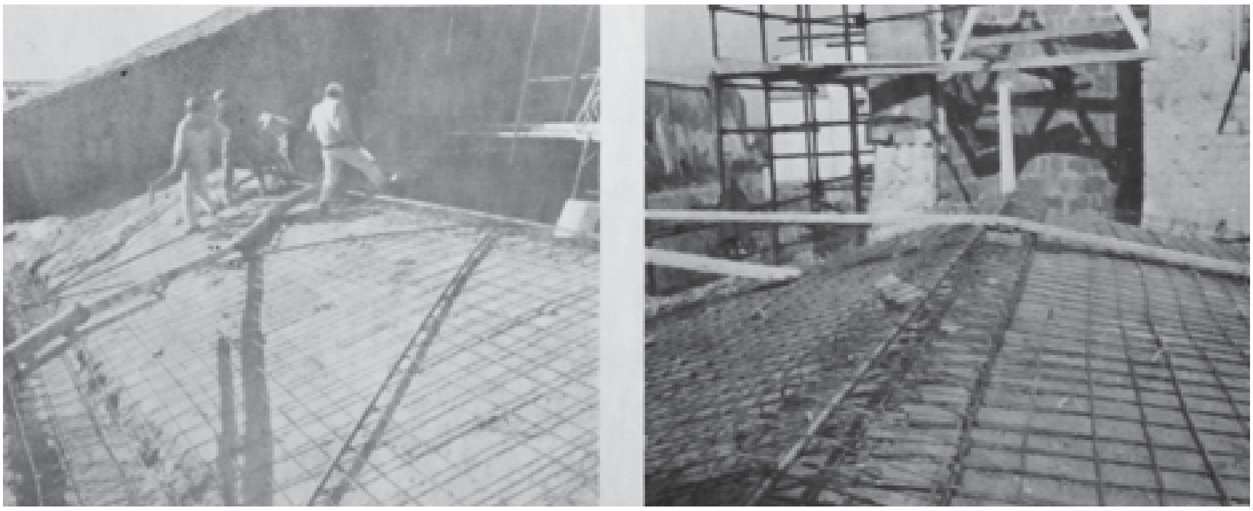


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

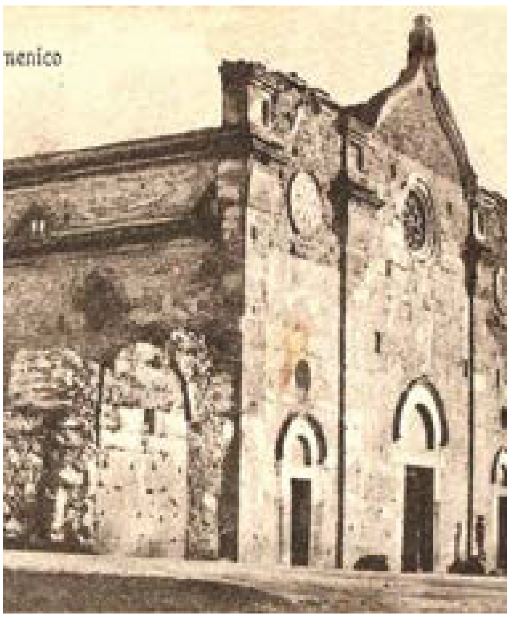
- *Carbonara (1981)*
- *Moretti Ma. (1983)*
- *Raspi Serra (1971, 1972)*
- *Staccini (2005)*
- *Swedish National Heritage Board (1932)*

SAN DOMENICO'S ABBEY

Sora (FR)

Description

The monastery has not reached its original appearance to date, due to the many restorations. The latest devastating earthquake of January 13, 1915 practically destroyed the entire vaulted ceiling. Today the abbey has a rather sober main facade, with three doors and a beautiful central rose window. The jambs of the left door and the left door of the portal are made of limestone blocks with rural motifs, rectangular in shape. The interior of the church has three naves, divided by a double row of pillars that enclose the columns of the original church. On the walls there are elegant pointed arches that give momentum and solemnity to the interior.



Code: A_4 | 7

Analyzed Restoration Intervention

Period of restoration	**1973-1980**
Client	**Soprintendenza per i Beni Architettonici e Ambientali del Lazio**
Designer	/
Company	/

The restoration intervention aimed to solve the various instabilities of the church, due to the phreatic subsoil and to the consequence displacements of the foundations. The intervention provided the insertion of a series of poles in reinforced concrete along the perimeter of the church, connected by the insertion of foundation beams in reinforced concrete.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	**Foundations**

References

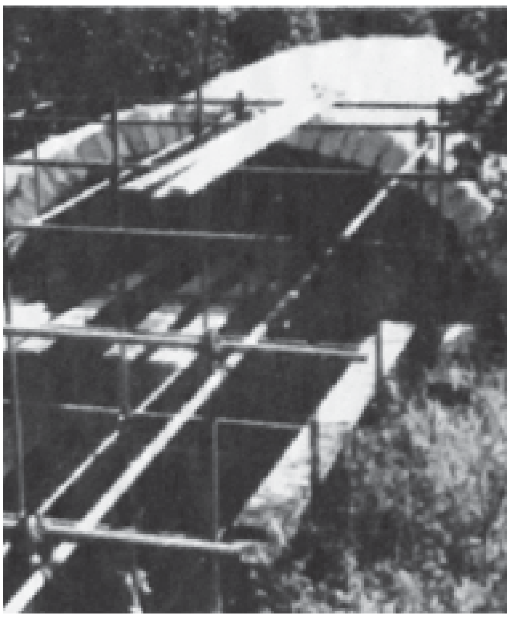
- *Carbonara (1981)*
- *Gavini (1915)*
- *Giorgetti (1994)*
- *Jetti, 1978)*
- *Loffredo (1981)*
- *ICCD, Archivio MPI*

CHURCH OF SAN LUCA

Guarcino (FR)

Description

The monastery seems to have been founded by San Benedetto around 528 AD and part of the building is overlooking the river. The church has a single nave, concluded by an apse with three windows. Until 1587 the monastery was assigned to the Benedictine nuns, and was sacked by the Napoleonic troops. The complete abandonment led the collapse of the roof from 1920, remaining exposed to the weather for lot of time.

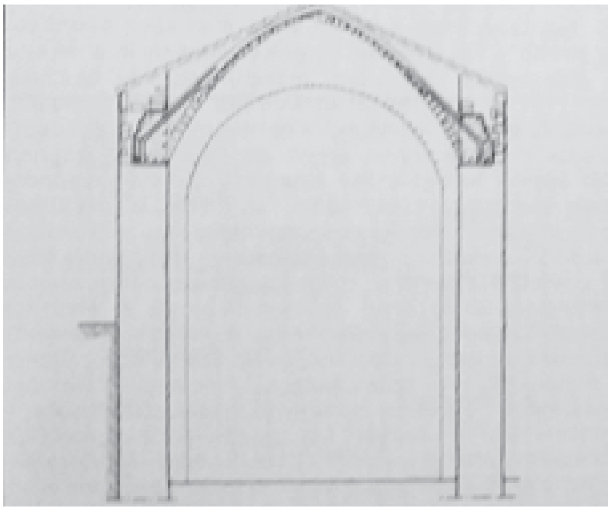


Code: A_4 | 8

Analyzed Restoration Intervention

Period of restoration	**1978-1980**
Client	**Soprintendenza per i Beni Architettonici e Ambientali del Lazio**
Designer	**G. Di Geso**
Company	**Aless**

The intervention interested the reinforcement and the structural improvement of the church, which suffered several damages due to the different failures of the structures. The restoration provided the reinforcement of the structural elements, such as the walls and the vaults, with the insertion of reinforced concrete beam and extrados vaults (in this last case the lightweight aggregates).



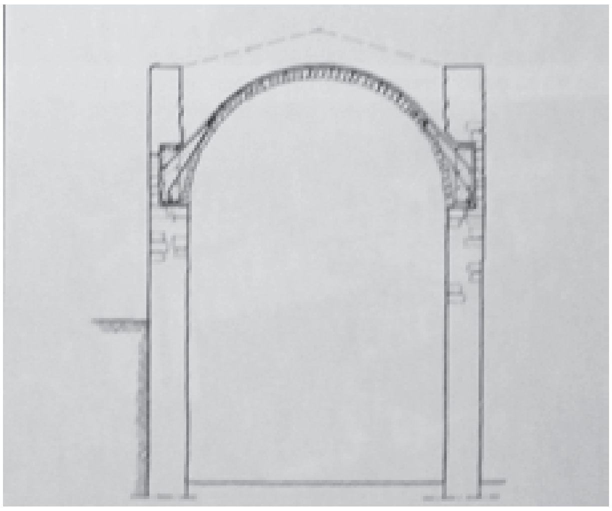


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Carbonara (1981)*
- *Scatena (2001)*

CHURCH OF SANTA MARIA MAGGIORE

Tuscania (VT)

Description

The Church of Santa Maria Maggiore in Tuscania stands on the slopes of the San Pietro hill. On the facade there are three finely decorated portals. The interior, with a basilica plan with a trussed roof, has three naves divided by six spans. There are frescoed columns and pillars, Romanesque capitals carved for round arches adorned in the arch by stylized four-petal flowers, above a stone frame on shelves with architectural and zoomorphic motifs. Along the walls of the side aisles we find blind arches that close blind arches on half-pillars. The presbytery is flanked by two transverse arches.

Code: A_4 | 9

Analyzed Restoration Intervention

Period of restoration	**1980**
Client	**Soprintendenza per i Beni Architettonici e Ambientali**
Designer	**G. Ruggieri**
Company	**/**

The restoration intervention consisted in the reinforcement of the left side of the church, which presented huge displacements. In this way, it has been realized a frame in reinforced concrete, able also to remove the external buttresses, creating in support of the church, already failuring in the interested side.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Angelelli (2011)*
- *Carbonara (1981, 1995)*
- *Demetrescu (1997)*
- *Moretti Ma (1983)*
- *Parlato (2001)*
- *Raspi Serra (1971, 1972)*
- *Ricci (1996)*
- *Staccini (2005)*

ICCD, Gabinetto Fotografico

MISSION SAN ANTONIO DE VALERO | THE ALAMO

San Antonio (TX)

Description

Mission San Antonio De Valero, commonly reknown as the Alamo, is the first Franciscan mission established in San Antnio Texas. Built as the Franciscan mission, it was initially a place with services for the natives, as schools, shops, residential headquarters. The church was designed according to the rule of Spanish architecture. With the secularization of the missions, also San Antonio de Valero had been abandoned by the friars in 1793. With the occupancy of Texan soldiers, the building maintained for other two years its defensive purpose, but becoming the Texan fort; it was the beginning of the battle of the Alamo. Adina De Zavala, with the Daughters of Republic of Texas (DRT) resumed the restoration and retained the custodian of the building. They called for the project the architect Alfred Giles.

Code: B_1 | 1

Analyzed Restoration Intervention

Period of restoration	**1921**
Client	**Daughters of the Republic of Texas | DRT**
Designer	**Alfred Giles**
Company	**/**

The Mission San Antonio De Valero was restored in 1921 by Architect Alfred Giles, which designed a new roof in a reinforce concrete structure; the founds of the interventions had given by the Daughters of Republic of Texas which sold the pieces of the old roof, among other donations by privates and associations, for founding enough money for the restoration. The project by Alfred Giles aimed to preserve the interior of the building using a new structure, completely different from the timber structure of the roof preexisting, made by arch, top beams and vault in reinforced concrete.

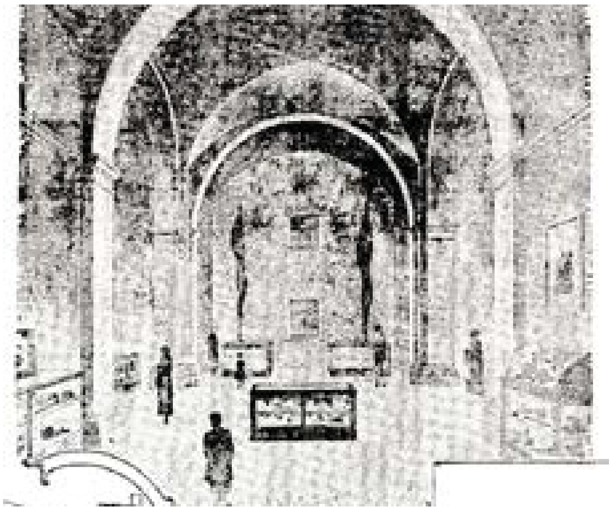


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Ables (1967)*
- *De Zavala (1917)*
- *Felli et al. (2019)*
- *Flores (2002)*
- *Habig (1968 a, b)*
- *Ivey (1997)*
- *Meissner (1996)*
- *Newcomb (1926)*
- *Roberts et al. (2001)*
- *Tabor Linenthal (1988)*
- *Thompson (2005)*
- *HABS, LIBC, UTA_AAA*

MISSION ESPIRITU SANTOS

Goliad (TX)

Description

In 1722 the Marqués de Aguayo authorized Father Agustín Patrón y Guzmán to establish Nuestra Señora del Espíritu Santo de Zúñiga Mission, commonly called La Bahía. On March 24, 1931, the city of Goliad and Goliad County transferred the site to the state, which agreed to preserve it as a historical park. During Franklin D. Roosevelt's New Deal (1933–41), federal public-works projects conducted archeological, historical, and architectural research at the mission site, and its buildings were then restored with local Civilian Conservation Corps labor under the supervision of the National Park Service and the University of Texas. Additional reconstruction occurred in the 1960s, and by 1987 the mission appeared as it did in 1749.

Code: B_1 | 2

Analyzed Restoration Intervention

Period of restoration	**1934**
Client	**Goliad Municipality**
Designer	**A.B. Ayres, R.M. Ayres**
Company	**/**

The restoration intervention pursued by the architects Ayres aimed to redifine the volume of the original church; in this way, the architects proposed the construction of a singla nave building, with a central tower bell above the facade, with a single nave, whose termination presented different grade in comparison to the facade and the square angles of the walls. Before the reconstruction, which interested larga part of the building, the foundation had been reinforced with a plate in reinforced concrete.

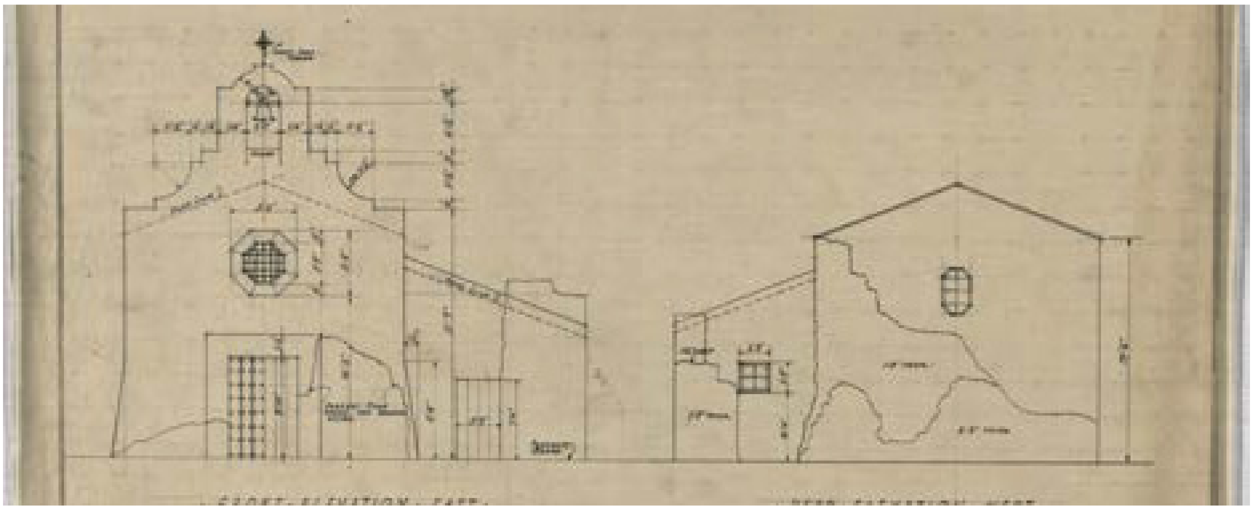


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

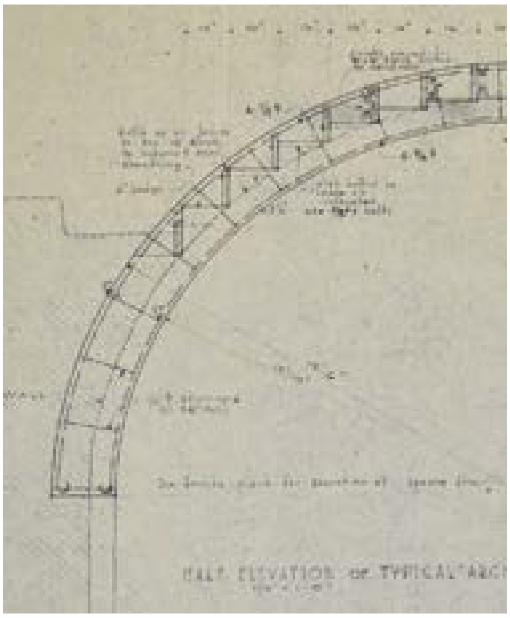
- *Alessio (1996)*
- *Almarez (1996, 1997, 2003)*
- *Benoist et al. (1994)*
- *Lee (1990)*
- *Leffingwell (2005)*
- *McCaleb (1961)*
- *Spanish Missions (1921)*
- *UTA_AAA*

MISSION SAN JOSE Y SAN MIGUEL AGUAYO

Location

Description

San José y San Miguel de Aguayo, the "Queen of the Missions," is the largest mission in San Antonio, established in 1720 and completed in 1782. Spanish designers, directing workers from the local Coahuiltecan tribe, built the mission using Texas limestone and brightly colored stucco. At its height, it provided sanctuary and a social and cultural community for more than 300 Indians. During the period from the end of 60s and the beginning of the 70s in the 19th century, the church had been a lot of damages. One at the end of 60s period, in 1868, in which the north wall of the church collapsed. In 1874, San José's church dome and roof collapsed. In 1928, the church tower collapsed. The Works Progress Administration (WPA) almost fully restored Mission San José to its original design in the 1930s.



Code: B_1 | 3

Analyzed Restoration Intervention

Period of restoration	**1933-1937**
Client	**San Antonio Municipality**
Designer	**Harvey Smith**
Company	**Frederick Schutte Construction Company**

The coating of the dome, made entire in reinforced concrete worked in site, is supported on a circular beam (even in reinforced concrete), sustained by a series of pillars, linked to the main ring beam, of octagonal form and realized in steel. As it seems from the drawings, but we need more detailed studies, also the arch which support the vault are made in reinforced concrete. There are also photos during the work of restoration in which we can see the structure of the dome without the bricks of tamponation.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

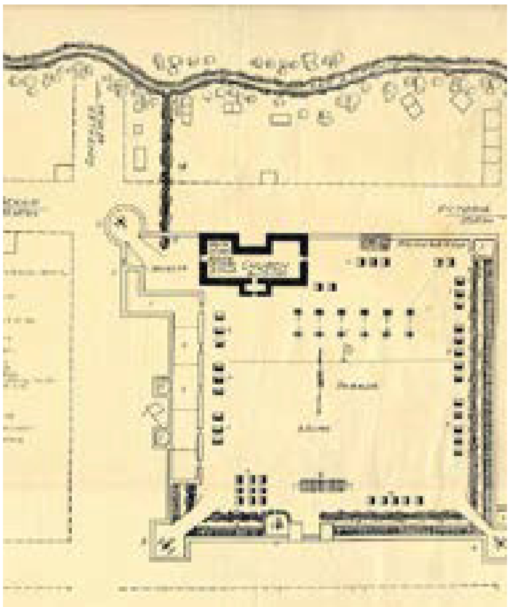
- *Almaraz (2003)*
- *Benoist et al. (1994)*
- *Correira (2006)*
- *Fisher (1998)*
- *Ford Powell & Carson (2003)*
- *Ivey et al. (2006)*
- *James and Suarez (1995)*
- *Lee (1990)*
- *McCaleb (1961)*
- *S. A. Missions Historical Park (1995)*
- *Spanish Missions (1921)*
- *UTA_AAA, TSA, HABS*

MISSION LA BAHIA (PRAESIDIO)

Goliad (TX)

Description

The Presidio Nuestra Señora de Loreto de la Bahía, known more commonly as Presidio La Bahía, or simply La Bahía is a fort constructed by the Spanish Army that became the nucleus of the modern-day city of Goliad, Texas, United States. The current location dates to 1747. Today, the presidio is probably most famous for the part it played the Texas Revolution: namely the Battle of Goliad in October 1835, and the Goliad Massacre in March 1836. It was restored in the 1960s and became a National Historic Landmark in 1967. While several adjacent historical sites in Goliad are now part of the Texas state parks system, La Bahía is owned by the Catholic Diocese of Victoria, Texas but operates as public museum. It continues to be the subject of noted archaeological research.



Code: B_1 | 4

Analyzed Restoration Intervention

Period of restoration	**1963-1968**
Client	**National Park Service**
Designer	**Raiford Stripling**
Company	**/**

The restoration works provided the recreation of the building, which had been re-constructed in large part. With the works, the church recovered the original size, with the additions of masonry elements. The new structure of the roof presents reinforced concrete top beams, able to connect the entire system.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Alessio (1996)*
- *Almarez (1996, 1997, 2003)*
- *Benoist et al. (1994)*
- *Lee (1990)*
- *Leffingwell (2005)*
- *McCaleb (1961)*
- *Spanish Missions (1921)*
- *Walters (1951)*
- *UTA_AAA*
- *LIBC*

MISSION SAN JUAN BAUTISTA

San Juan (CA) | First intervention

Description

Mission San Juan Bautista is a Spanish mission in San Juan Bautista, San Benito County, California. The mission had been founded in 1794, and whose system with a single nave had been modified from 1808 to 1814 after a series of quake events, presents a size three time bigger than the original, with the walls' height of 12m, the highest never realized; there are also a nartex in the front façade, positioned continually with the lateral convento The mission suffered the earthquake of 1906, which involved the walls of the church going out of plumb line. The architecture of today is the result of different modifications; in particular, the interior, which probably originally was single nave, in the Seventy years had been enlarged with other two smaller naves.

Code: B_2 | 1

Analyzed Restoration Intervention

Period of restoration	**1926**
Client	**San Juan Bautista State Historic Park**
Designer	/
Company	/

After 1906 earthquake, the diffused out of lead situation of the main walls did not involve shared solution for the restoration, to the point that the first decision after the damages had taken only in 1926, seventeen years after the earthquake. In the first restoration project, the collapsed parts, as also the espadana and the tower bell, were rebuilt, while the main walls of the nave were left in their oblique position, with the insertion of external buttresses in reinforced concrete and small thickening – always in reinforced concrete - at the bases of the walls.

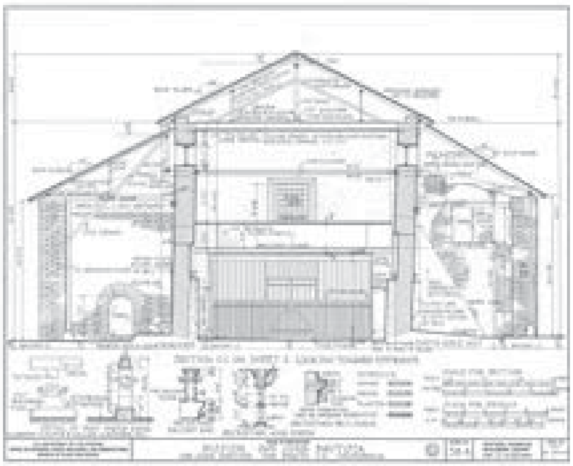


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

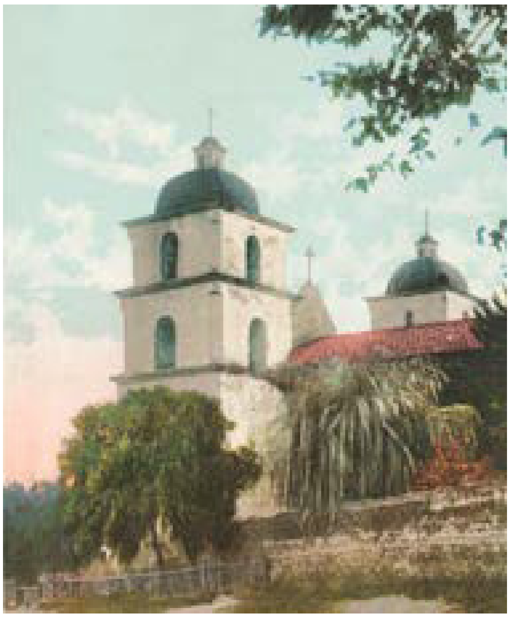
- *Aiken (1983)*
- *Chapman (1936)*
- *Coffee (2011)*
- *Engelhardt (1931)*
- *Forbes (1937)*
- *Kimbro (2009)*
- *Mission Memories (1900)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *Weddle (1968)*
- *SJHS, HABS, TSL*

MISSION SANTA BARBARA

Santa Barbara (CA)

Description

Santa Barbara Mission, is a Spanish mission founded by the Franciscan order near present-day Santa Barbara, California. It was founded by Padre Fermín Lasuén on December 4, 1786, the feast day of Saint Barbara, as the tenth mission for the religious conversion of the indigenous local Chumash-Barbareño tribe of Native American people. This major mission has a distinctive church with a Neoclassical façade, characterized by the two bell tower at the sides, the pillars and a huge gable. The interior is single nave, with horizontal and wooden decorated ceilingand, and presents some lateral chapels and windows.



Code: B_2 | 2

Analyzed Restoration Intervention

Period of restoration	**1925-1927**
Client	**California State Park Commission**
Designer	**Ross Montgomery**
Company	/

After the earthquake in 1925, which involved lots of damages to the entire church, the intervention of restoration aimed to create a new structure able to support the new roof, not only with concrete beams at the top of the church, but also with buttresses in reinforced concrete, limiting overturning stresses in the chapels. Other elements as the baptistery (and also the bell tower above it), the other belfry, the choir and the new sacristy, are made in reinforced concrete walls. The other elements of the complex, monastery, new sacristy, library and convent are reinforced with an independent structure in reinforced concrete, with the addition of new columns and the thickening of existing walls (in the new sacristy) with reinforced concrete.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Aiken (1983)*
- *Chapman (1936)*
- *Forbes (1937)*
- *Graffly (2010)*
- *Kimbro (2009)*
- *Montgomery (1925)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *Staats (1929)*
- *Weeks-Wilson (1913)*
- *NYPL, UCLA, HABS*

SAN LUIS OBISPO DE TOLOSA

San Luis Obispo (CA)

Description

Founded by Father Junipero Serra in 1772, the church of Mission San Luis Obispo de Tolosa perches above a small plaza in the heart of the city that grew up around it. The Mission of San Luis Obispo is unusual in its design, in that its combination of belfry and vestibule are found nowhere else among the California missions. Like other churches, the main nave is short and narrow, but at the San Luis Obispo Mission, there is a secondary nave of almost equal size situated to the right of the altar, making it the only L-shaped mission church in California. The front facade is characterized by the presence of a nartex, which had been continouslly added and removed over the times, and a particular bell fry (which also, being part of the facade, had been removed and added more times).

Code: B_2 | 3

Analyzed Restoration Intervention

Period of restoration	**1933-1936**
Client	**Church of California | National Park Service**
Designer	**Work Progress Administration**
Company	/

The restoration intervention focues on the formal aspect of the church. With the modification inducted during times, the project aimed to remove the modification and give back the original aspect, in particular of the facade. In this way, the front nartx, which had been removed, was rebuilt, using for the structural elements reiforced concrete elements, such as columns and beams (in the plane of the facade). Also, the first level of the nartex had been linked to the existing structure with beams in reinforced concrete.

Also the other nave, added, presents walls in concrete.

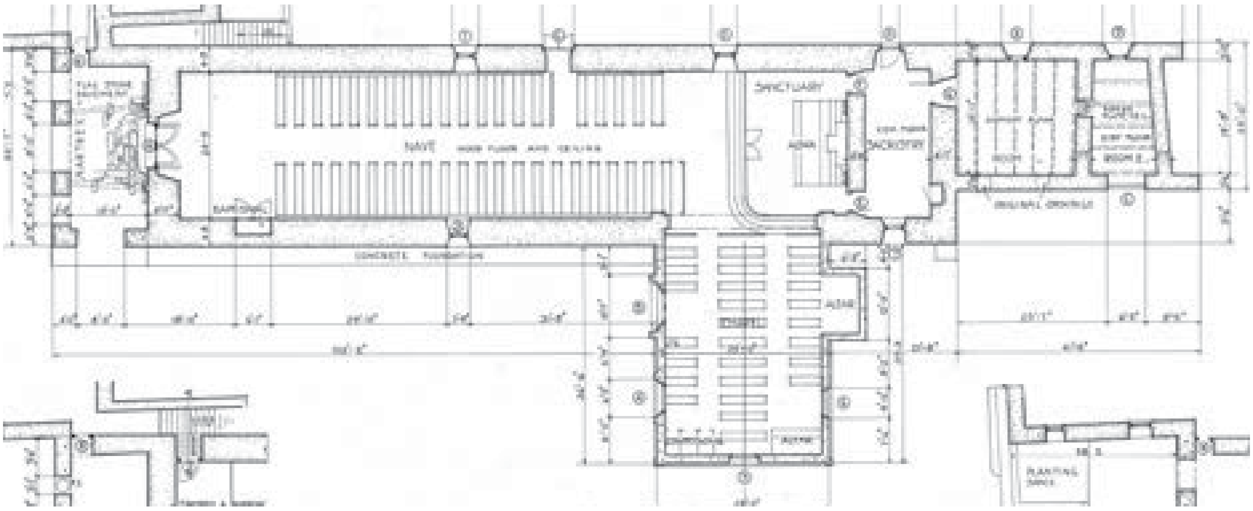


Table of restoration's cataloguing

PHASE 0	Earthquake	**Elements in reinforced concrete**
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	Top and bond beams' insertion
	War	Reinforced concrete frame's insertion
PHASE 3	**Reinstatement**	Foundations

References

- *Aiken (1983)*
- *Chapman (1936)*
- *Engelhardt (1963)*
- *Forbes (1937)*
- *James (1923)*
- *Kessel (2002)*
- *Kimbro (2009)*
- *Mission Memories (1900)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *HABS, USC*

MISSION SAN MIGUEL ARCANGEL

San Miguel (CA)

Description

In 1845, Governor Pío Pico declared the Mission buildings for sale and, in 1846, made Mission San Fernando Rey de España. The Mission was utilized in a number of ways during the late 19th century: north of the mission was the site of Lopez Station for the Butterfield Stage Lines; it served as a warehouse for the Porter Land and Water Company; and in 1896, the quadrangle was used as a hog farm. The buildings were disintegrating, as beams, tiles and nails were taken from the church by settlers. San Fernando's church became a working church again in 1923 when the Oblate priests arrived. Many attempts were made to restore the old Mission from the early 20th century, but it was not until the Hearst Foundation gave a large gift of money in the 1940s.

Code: B_2 | 4

Analyzed Restoration Intervention

Period of restoration	**1934-1937**
Client	**Hearst Foundation**
Designer	**Jess Crettol**
Company	**/**

Mission San Miguel Arcangel, whose restoration had been realized in 1934, presented a widespread state of decay among all the elements before the intervention. The project intended to restore the original spaces, with the remaking of the roof, in faliure, and the addition of other structural elements. The roof had been realized in timber trusses, supported by a perimetral system of top beams, realized in rerinforced concrete. Also in the convento's portico, reinforced concrete had been used in the longitudinal top beams, supporting the roof.

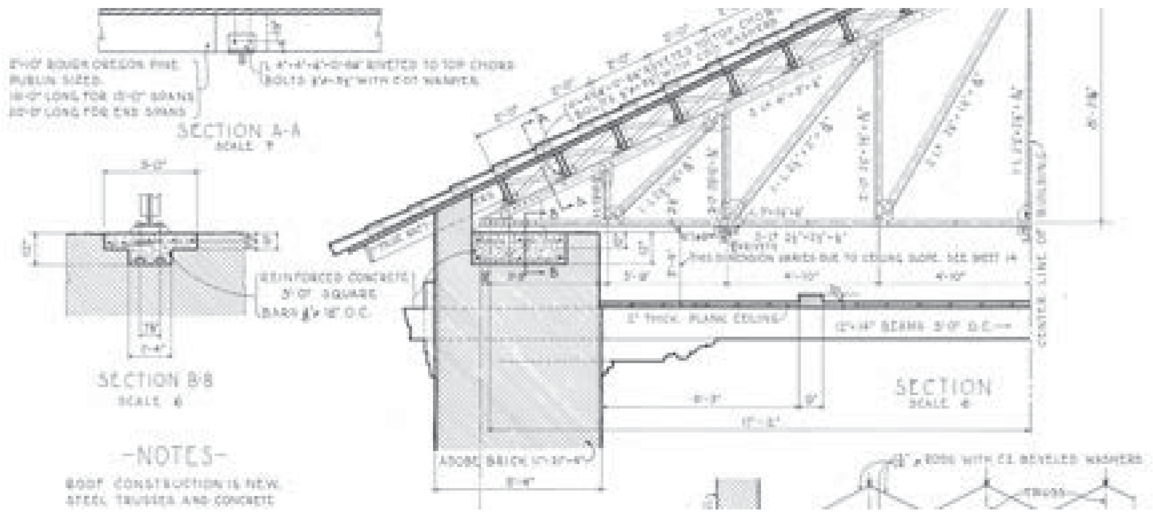


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	**Decay**	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Aiken (1983)*
- *Baer (1958, 1961)*
- *Chapman (1936)*
- *Engelhardt (1929)*
- *Forbes (1937)*
- *Hannaford (1931)*
- *Kimbro (2009)*
- *Mission Memories (1900)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *HABS, NYPL, USC*

MISSION SAN FERNANDO REY DE ESPANA

San Fernando Valley (CA)

Description

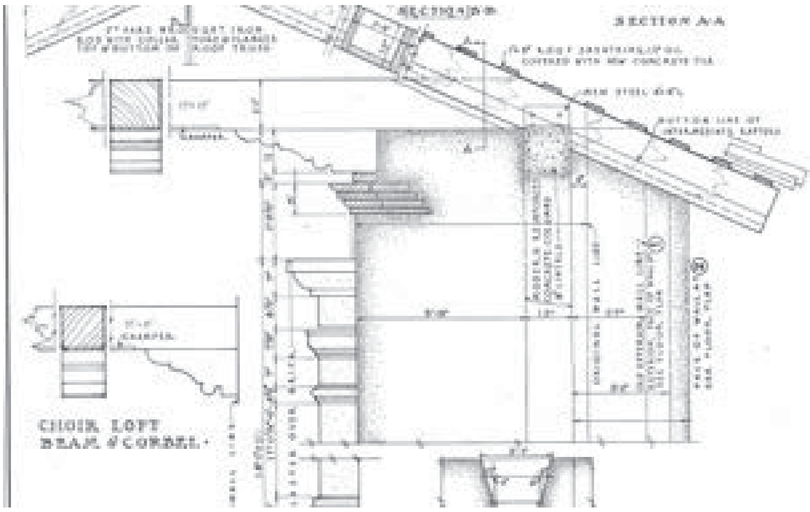
Mission San Fernando Rey de España is a Spanish mission in the Mission Hills district of Los Angeles, California. The mission was founded on September 8, 1797. Named for Saint Ferdinand, the mission is the namesake of the nearby city of San Fernando and the San Fernando Valley. In 1845, Governor Pío Pico declared the Mission buildings for sale and, in 1846, made Mission San Fernando Rey de España de velicata his headquarters as Rancho Ex-Mission San Fernando. It served as a warehouse for the Porter Land and Water Company; and in 1896, the quadrangle was used as a hog farm. In 1861 the Mission buildings and 75 acres of land were returned to the church, after Charles Fletcher Lummis acted for preservation.

Code: B_2 | 5

Analyzed Restoration Intervention

Period of restoration	**1923-1941**
Client	**National Park Service**
Designer	**Work Progress Administration**
Company	/

Mission San Fernando Rey, interested by a serious state of decay, had been restored with aim of the recreation of the original spaces. According to the state of failure of the interested systems, the roof had been rebuilt in wood, supported by a systems of top beams and columns, inside the mansonry, realized in reinforced concrete. The wokrs took lot of times, but the final phase of work, with the contribution of the HABS and the Work Progress Administration took a relatively short period.



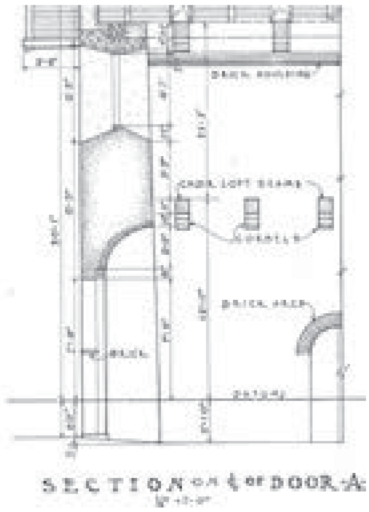


Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	Top and bond beams' insertion
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Aiken (1983)*
- *Baer (1958, 1961)*
- *Chapman (1936)*
- *Forbes (1937)*
- *Jennings et al. (1973)*
- *Johnson (1964)*
- *Kimbro (2009)*
- *Mission Memories (1900)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *HABS, NYPL, USC*

MISSION SAN JUAN BAUTISTA

San Juan (CA) | Second intervention

Description

Mission San Juan Bautista is a Spanish mission in San Juan Bautista, San Benito County, California. The mission had been founded in 1794, and whose system with a single nave had been modified from 1808 to 1814 after a series of quake events, presents a size three time bigger than the original, with the walls' height of 12m, the highest never realized; there are also a nartex in the front façade, positioned continually with the lateral convento The mission suffered the earthquake of 1906, which involved the walls of the church going out of plumb line. The architecture of today is the result of different modifications; in particular, the interior, which probably originally was single nave, in the Seventy years had been enlarged with other two smaller naves.

Code: B_2 | 6

Analyzed Restoration Intervention

Period of restoration	**1975-1978**
Client	**National Park Service | Diocese of Monterey**
Designer	**H. Downie, M. Taylor, G. Sanchez**
Company	**M. Taylor**

The second intervention of restoration aimed to redifine the original form and system of the church. providing the reopening of the two lateral aisles, instead of the only one left after the earthquake of 1906. In particular, with also the reconstruction of the roof, realized in wooden structure, the supporting system above the walls consisted in a perimetral top beam realized in reinforced concrete.

Table of restoration's cataloguing

PHASE 0	Earthquake	Elements in reinforced concrete
PHASE 1	Hurricanes / floodings / winds	New roof in reinforced concrete
PHASE 2	Decay	**Top and bond beams' insertion**
PHASE 3	War	Reinforced concrete frame's insertion
	Reinstatement	Foundations

References

- *Aiken (1983)*
- *Chapman (1936)*
- *Coffee (2011)*
- *Engelhardt (1931)*
- *Forbes (1937)*
- *Kimbro (2009)*
- *Mission Memories (1900)*
- *Neuerburg (1987)*
- *Newcomb (1914)*
- *Sewall (2013)*
- *Weddle (1968)*
- *SJHS, HABS, TSL*

Sources

ANNOTATED BIBLIOGRAPHY CONSULTED ARCHIVES AND GRAPHIC SOURCES

Riferimenti

Bibliografia ragionata, archivi consultati e fonti iconografiche

Mission San José y San Miguel Aguayo, San Antonio, Texas. Detail (HABS, 1983)

General Acknowledge

The chosen bibliography is reported according to the different topic analyzed in the chapters, as:

- *General Bibliography,* which includes the reference and consulted bibliography about the history of architecture and restoration fields, focusing on both the areas of the research;
- *Specific bibliography for the Italian case studies* and *Specific bibliography for the American case studies,* which include the consulted bibliography about the restoration interventions pursued in the areas of study;
- *Bibliography about the international laws,* which include all the contribution in the international debate, with rules and theories (in this last cases there are reported also the consulted local guidelines).

The graphical sources are listed for each used picture of the dissertation, divided in chapters. The consulted archives report also the used abbreviations.

According to the declared authorization of Soprintendenza Archivistica e Bibliografica dell'Abruzzo e del Molise, Soprintendente Dott. Domenico Leone, IT IS STRICTLY FORBIDDEN REPRODUCE OR COPY ALL THE DOCUMENTS AND IMAGES REPORTED IN THE DISSERTATION from the Genio Civile Historical Archive, Archivio Diocesano dei Marsi, all the archives of Soprintendenza, all the historical archives of the mentioned Municipalities, the private historical archives of Barattelli company and Inverardi studio and all the private archives.

It is also strictly forbidden reproduce and copy the images and the documents from the historical archives of National Park Service, Daughters of Republic of Texas, Bexar County and General Land Office.

The present works had been realized also thanks to the possibilities and availabilities of:

- Barattelli Company of L'Aquila, for the research in the private archive of their company;
- Inverardi Studio of L'Aquila, for the research in the private historical archive of the studio of engineers;
- Soprintendenza ABAP of Abruzzo, section of Avezzano, for the possibility of research in their historical archives;
- Soprintendenza Archivistica e Bibliografica dell'Abruzzo e del Molise, for the kind availability of the functionaries;

- The University of Texas at San Antonio, in particular the Dean of the Department of Architecture John Murphy, the professors Angela Lombardi and William Dupont and the head of the Department professor Sedef Doganer;
- Ufficio Genio Civile of Avezzano, with also the collaboration of the functionaries of the Soprintendenza Archivistica of Abruzzo and Molise, for the research condutcted in their historical archives and deposits.
- The National Park Service, in particular the functionary Dr. Susan Snow.

Also, sincere thanks to all the responsible and functionaries of the consulted archives in Italy and in Texas for their availability and kindness.

BIBLIOGRAPHY

General Bibliography

(1885), *Restauro e recupero. Esperienza congiunta di una soprintendenza e di una comunità montana nell'attività di salvaguardia e valorizzazione dei beni architettonici e ambientali*, Soprintendenza ai beni ambientali, architettonici artistici e storici per l'Abruzzo, Comunità Montana zona C sirentina Secinaro, L'Aquila.

(1915), *L'orrendo terremoto del 13 gennaio 1915,* New York, February 8th.

(1931), *The Athens Charter for the Restoration of Historic Monuments*, in *La conservation des monuments d'art e d'histoire,* Paris: Institut de Coopération Intellectuelle, 402–407.

(1982). *La fotografia come memoria della città: L'Aquila tra Ottocento e Novecento, Azienda Autonoma Soggiorno e Turismo*, L'Aquila, Soprintendenza ai Beni Architettonici, Artistici, Ambientali e Storici dell'Abruzzo.

(1983), *La protezione del patrimonio monumentale dal rischio sismico – Termin del problema,* Rome: Istituto Centrale per il Restauro.

(1984), *Architettura e Arte nella Marsica*. Rome: Marcello Ferri Editore.

(1986), *La valle del medio e basso Vomano*, Teramo: Edigrafital.

(1988), *Abruzzo dei castelli,* Pescara: Carsa.

(1996), *Il Sistema Hennebique,* in CASOTTO, A., SARAIN, M., STIEVANO, B., *Il recupero dell'area dell'ex macello di Padova a biblioteca polifunzionale di area medica,* Thesis in Architecture, Venice, available at https://www.sacs.it/tesi/c004.htm

(2008), *The 1908 Messina Earthquake: 100-Year Retrospective,* RMS Special Report, Risk Management Solution Inc., available at http://forms2.rms.com/rs/729-DJX-565/images/eq_1908_messina_eq.pdf

(2016), *100 anni terremoto Avezzano. Atti delle conferenze per il centenario del terremoto del 13 gennaio 1915*, Cerchio-Avezzano: Edizioni Kirke

(2017), *Archivio Antonino Giuffrè (1958 – 1997). Inventario*. Rome: Soprintendenza Archivistica e Bibliografica del Lazio.

ABBATE, E. (1903), *Guida dell'Abruzzo,* Bologni: Forni Editore (anast. ed. 1984)

ACI (American Concrete Institute) (2014), *Guide for Tolerance Compatibility in Concrete Construction,* ACI 117.1R-14

AGNEW, N., PREUSSER, F., DRUZIK, J. R. (1988), *Strategies for Adobe Preservation,* in *5th International Meeting of Experts on the Conservation of Earthen Architecture, Rome, ICCROM,* Grenoble France: Guirimand.

AGOSTINONI, E. (1903), *Il Fucino,* Cerchio: Adelmo Polla Editore (anast. ed. 2001).

AIKEN, S. R. (1983), *The Spanish Missions of Alta California. Rise, Decline and Restoration,* in *Pioneer America,* Vol. 15, No. 1 (March), International Society for Landscape, Place & Material Culture, pp. 3-19.

ALOISIO, A., ALAGGIO, R., FRAGIACOMO, M. (2019), *Dynamic identification of a masonry façade from seismic response data based on an elementary Ordinary Least Squares approach,* in *Engineering Structures,* vol. 197, Elsevier.

ANDREANI, I. (1917), *Il progettista moderno di costruzioni architettoniche,* Milano: HOEPLI.

ANTINORI, L. (1717), *Annali degli Abruzzi dall'epoca preromana sino all'anno 1717 dell'era volgare,* Bologna: Forni (anast.ed. 1971-73).

ANTINORI, L. (1781), *Raccolta di Memorie Istorische delle tre provincie degli Abbruzzi,* Naples: Giuseppe Campo.

ANTONINI, O., (1988), *Architettura religiosa aquilana*, L'Aquila. Edizioni del Gallo Cedrone

ARGAN, G.C. (1968), Word definition of *Architettura,* in *Dizionario enciclopedico di Architettura e Urbanistica I,* pp. 141-142.

AUGENTI, N., PARISI, F. (2010), *Learning from Construction Failures due to the 2009 L'Aquila, Italy, Earthquake,* in *Journal of Performance of Constructed Facilities,* ASCE, November/December.

AVENA, D. (1902), *Monumenti dell'Italia Meridionale,* Rome: Officina Poligrafica Romana.

BADIALI, G. (1912), *Alcune cose importanti condotte a termine durante il mio incarico. 1910-1912*, Rome: Tip. Pistolesi

BALDINI, U. (1978), *Teoria del restauro e unità di metodologia,* Firenze: Nardini.

BALZANO, V. (1911), *Note d'arte abruzzese,* in *Rivista abruzzese di scienze lettere e arti*, Palazzo dei Tribunali in Aquila

BARBATO, G., DEL BUFALO, A. (1978), *L'Abruzzo e i centri storici della provincia dell'Aquila*, L'Aquila: Marcello Ferri editore.

BARTOLINI SALIMBENI, L. (1993), *Architettura Francescana in Abruzzo: dal XIII al XVIII secolo*, Rome: Edilgrafica.

BARTOLINI SALIMBENI, L. (1993), *Architettura francescana in Abruzzo dal XIII al XVIII secolo,* I saggi di Opus, volume 2, Roma: Edilgrafica.

BARTOLINI SALIMBENI, L. (1998), *Delle tipologie religiose nell'architettura abruzzese fra XI e XIX secolo*, in *Abruzzo. Rivista dell'Istituto di Studi Abruzzesi, a. XXXVI*.

BARTOLOMUCCI, C. (2015), *Gli effetti del terremoto del 1915 nella città dell'Aquila: I danni e gli orientamenti per il restauro,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il* *circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

BARTOLOMUCCI, C. (2016), *La dialettica tra eresie e ortodossie nei restauri in Abruzzo, dagli anni Sessanta all'attuale 'ricostruzione' post sismica,* in DRIUSSI, G., BISCONTIN, G., ed., *Eresia ed Ortodossia nel Restauro. Progetti e realizzazioni,* Scienza e Beni Culturali, Edizioni Arcadia Ricerche.

BARTOLOMUCCI, C., COLAPIETRA, R., CENTOFANTI, M. (1997), *L'Aquila: I Palazzi,* L'Aquila: Ediarte.

BELLINI, G. M. (1889), *L'Arte in Abruzzo. Brevi notizie di varii monumenti abruzzesi dichiarati nazionali*, Lanciano: Tomassini

BELTRAMI, L. (1892), *La conservazione dei monumenti nell'ultimo ventennio,* Rome: Tipografia della Camera dei Deputati.

BENEVOLO, L. (1957), *L'esigenza di conservare gli ambienti antichi non significa bloccare ogni iniziativa. Per conservare bisogna modificare la realtà*, in *L'Architettura. Cronache e Storia*, III, 1957, 21, p. 182.

BENVENUTO, E. (1991), *An introduction to the History of Structural Mechanics,* New York: Springer, Verlag.

BERNARDI, A., (1999), *Ricostruzione e restauro dei monumenti marsicani*, in "Marsica 1915", in CASTANETTO, S., GALADINI, F., ed., *13 gennaio 1915. Il terremoto della Marsica*, Roma: istituto Poligrafico e Zecca dello Stato.

BERTAUX, E. (1904), *L'art dans l'Italie méridionale de la fin de l'Empire Romaine à la conquéte de Charles d'Anjou*, Paris: Fontemoing

BERTOLINI, L., ELSENER, B., PEDEFERRI, P., POLDER, R.B. (2004), *Corrosion of Steel in Concrete: prevention, diagnosis, repair.*

BINDI, V. (1889), *Monumenti artistici e storici degli Abruzzi*, Naples: Reale Tipografia commerciale F. Giannini e figli.

BIOLCHI, R. (1930), *Un monumento romanico in Abruzzo: la Basilica di Santa Giusta di Bazzano,* in *Bollettino d'Arte, X,* III, September.

BISCONTIN, G. (1993), *Calcestruzzi antichi e moderni: Storia, Cultura e Tecnologia,* in *Atti del Convegno di Studi,* Padua: Libreria Progetto.

BISCONTIN, G., DRIUSSI, G. (2004), ed., *Architettura e materiali del Novecento: Conservazione, restauro, manutenzione,* in *Atti del Convegno di Studi,* Venice: Arcadia Ricerche.

BLASI, C. (2013), ed., *Architettura storica e terremoti. Protocolli operativi per la conoscenza e la tutela*, Milanofiori Assago: Wolters Kluwer Italia.

BOITO, C. (1884), *I restauratori,* Florence: G. Barbera.

BOITO, C. (1893), *Questioni pratiche di belle arti,* Milan: HOEPLI.

BONELLI, R. (1984), *Considerazioni finali,* in CARBONARA, G. (1984), ed., *Restauro e cemento in architettura 2,* Roma: Associazione Italiana Tecnico Economica del Cemento.

BONELLI, R. (1988), *Restauro: l'immagine architettonica tra teoria e prassi,* in *Storia Architettura,* XI, 1-2.

BORRI, A. (2010), *Costruzioni storiche e qualità muraria: problematiche e possibili interventi di consolidamento,* in Proceedings of *Sicurezza e Conservazione nel Recupero dei Beni Culturali Colpiti da Sisma,* Venice.

BORRI, A., et al. (2017), *Analisi del danno degli edifici ordinari nel centro storico di Norcia a seguito dei sismi del 2016,* in *Contributi al XVII Congresso Nazionale. "L'ingegneria sismica in Italia"*, Pistoia.

BOSCARINO, S. (1984), *Aspetti tecnici nel restauro dei monumenti*, in *Simposio sul tema "Prospettive della ristrutturazione e consolidamento dei monumenti siciliani, Siracusa, 15 marzo 1984*".

BRANDI, C. (1957), *Uno sgomentante puzzle risolto per amore dell'arte*, in *Corriere della Sera*, December 27th.

BRANDI, C. (1963), *Teoria del restauro,* Torino: Piccola biblioteca Einaudi.

BROGI, T. (1950), *La Marsica antica, medievale e fino all'abolizione dei feudi,* Rome.

BRUSAPORCI, S. (2007), *Le murature nell'architettura del versante meridionale del Gran Sasso (sec. XI-XIV),* Rome: Gangemi Editore

BRUSAPORCI, S. (2012), *Architetture per il sociale negli anni Trenta e Quaranta del Novecento,* Rome: Gangemi.

CALDERINI, C. (2008), *Use of Reinforced Concrete in Preservation of Historic Buildings: Conceptions and Misconceptions in the Early 20th Century,* in *International Journal of Architectural Heritage*, 2-1, 25-59.

CANTONE, G. (1980), *Opere fanzaghiane a Pescocostanzo*, in *Atti XIX C.*

CARBONARA, G. (1979), *Iussu Desiderii. Montecassino e l'architettura campano-abruzzese nell'undicesimo secolo,* Rome: Università degli studi di Roma.

CARBONARA, G. (1981), ed., *Restauro e cemento in architettura*, Roma: Associazione Italiana Tecnico Economica del Cemento.

CARBONARA, G. (1984), ed., *Restauro e cemento in architettura 2*, Roma: Associazione Italiana Tecnico Economica del Cemento.

CARBONARA, G. (1996), ed., *Trattato di restauro architettonico, vol. I,* Torino: UTET.

CARBONARA, G. (1997), *Avvicinamento al restauro. Teoria, storia, monumenti*, Napoli: Liguori.

CARBONARA, G. (2000), *Critica, estetica, metodologia e conservazione. Le tendenze attuali del restauro in architettura,* in *Enciclopedia Universale dell'Arte, II supplemento,* pp. 535-541.

CARBONARA, G. (2011), *Architettura d'oggi e restauro: un confronto antico-nuovo,* Turin: UTET.

CARBONARA, G. (2013), *Il restauro architettonico: formazione specialistica e strategie di politica culturale,* in FILIPOVIC, A., TROIANO, W., ed., *Strategie e Programmazione della Conservazione e Trasmissibilità del Patrimonio Culturale,* Roma: Edizioni Scientifiche Fidei Signa.

CARBONARA, G. (2017), *Il restauro fra conservazione e modificazione. Principi e problemi attuali,* in *Frequenze_conservazione/restauro,* Napoli: artstudiopaparo.

CASTANETTO, S., GALADINI, F. (1999), ed., *13 gennaio 1915. Il terremoto della Marsica*, Roma: istituto Poligrafico e Zecca dello Stato.

CAYME, J. C., ASOR, Jr N. (2017), *Characterization of Historical Lime Mortar from the Spanish Colonial Period in the Philippines,* in *Conservation Science in Cultural Heritage,* 16, pp. 33-57.

CECAMORE, S. (2015), *The reconstruction of L'Aquila, ancient and new devices,* in *ArcHistoR,* II, no. 4, pp. 118-151.

CECI, A. M., CONTENTO, A., FANALE, L., GALEOTA, D., GATTULLI, V., LEPIDI, M., POTENZA, F. (2010), *Structural performance of the historic and modern buildings of the University of L'Aquila during the seismic events of April 2009,* in *Engineering Structures,* 32(7), 1899-1924.

CENTANNI, C., PIERAGOSTINI, L. (1966), *La cattedrale di San Ciriaco ad Ancona. Rilievo metrico a grande scala, interpretazione strutturale e cronologia della fabbrica*, Ancona.

CENTOFANTI VERINI, A., (1969), *Note sulla storia della basilica di San Bernardino*, in *Bollettino della Deputazione Abruzzese di Storia Patria*

CENTOFANTI, M. (1975), *Struttura e forma urbana nei centri della media Valle dell'Aterno. Comunicazione al Convegno sui Centri Storici abruzzesi. Puntualizzazione sui caratteri e i modelli dell'architettura Gesuitica,* L'Aquila: Edizione la Bodoniana.

CENTOFANTI, M. (1979), *Fonti e documenti per la storia della città dell'Aquila: il ruolo del centro civico nella definizione della forma della città e le sue trasformazioni,* Lanciano: R. Carabba.

CENTOFANTI, M. (1983), *Cultura urbana, storia e progetto,* Roma: Istituto della Enciclopedia Italiana.

CENTOFANTI, M. (1984), *L'Aquila 1753-1983: il restauro della città,* L'Aquila: Libreria Colacchi.

CENTOFANTI, M. (1990), *Gustavo Giovannoni: il disegno della memoria, l'architettura della tradizione. 1897-1927,* L'Aquila: Tazzi.

CENTOFANTI, M. (1992), *L'Aquila, città di piazza: spazi urbani e tecniche costruttive,* Pescara: Carsa.

CENTOFANTI, M., BRUSAPORCI, S. (2011) a, *Il disegno della città e le sue trasformazioni*, in *Città e Storia*, VI, 2011, 1. Roma: Università Roma Tre-CROMA.

CENTOFANTI, M., BRUSAPORCI, S. (2011) b, *Il disegno della città e le sue trasformazioni,* in VAQUERO PINEIRO, M., CIRANNA, S., ed., *L'Aquila oltre I terremoti: costruzioni e ricostruzioni della città,* Rome: Università Roma Tre.

CENTOFANTI, M., DEL BUFALO, A., CIFANI, G. (1985), *Catalogo dei disegni di Gustavo Giovannoni conservati nell'archivio del centro di studi per la storia dell'architettura,* Roma: Centro Studi per la Storia dell'Architettura.

CHIARIZA, G., LATINI, M., PROPERZI, P. (2002) *Atlante dei castelli d'Abruzzo. Repertorio sistematico delle fortificazioni*, Pescara: Carsa.

CHIERICI, U. (1945) b, *Relazione sull'attività dell'Ufficio nel quadriennio 1942-1945*, Aquila.

CHIPMAN, D. E. (1992). *Spanish Texas, 1519–1821*. Austin: University of Texas Press

CHIRINI, M. (1954), *Silvestro Aquilano*, L'Aquila

CIFANI, G. (2013), *Gli insegnamenti dei terremoti passati,* in MARCHETTI, L., ALTORIO, E., ed., *MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009,* Avezzano: Officina Multimedia Abruzzo.

CINGOLI, A., CINGOLI, G., FONTANA, F. (2009), ed., *Impresa Cingoli Nicola e Figlio dal 1933. Aggiornamento 2009*, Colonnella: Martinintype.

CINGOLI, G. (1990), ed., *Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti*, Teramo: Edigrafital

CIPRIANI, C. A. (1999), *Aspetti della ricostruzione degli insediamenti urbani nella Marsica,* in CASTANETTO, S., GALADINI, F., ed., *13 gennaio 1915. Il terremoto della Marsica*, Roma: istituto Poligrafico e Zecca dello Stato.

CIRANNA, S. (2003), *L'immagine dei castelli abruzzesi nei viaggiatori dell'Ottocento,* in MARINO, A., *Fortezze d'Europa. Forme, professioni e mestieri dell'architettura difensiva in Europa e nel Mediterraneo spagnolo*. Rome: Gangemi, pp. 251-264.

CIRANNA, S. (2005), ed., *Abruzzo. Architettura a confronto: XIX e XX secolo*, Rome: Gangemi Editore

CIRANNA, S. (2009), *I danni al patrimonio dell'architettura moderna dell'Aquila: storia e cronaca a confronto,* in *Arkos. Scienza e Restauro,* 20, July/September, pp. 38-47.

CIRANNA, S. (2011), *L'architettura del potere: il rafforzamento del corso Vittorio Emanuele II e Federico II tra XIX e XX secolo,* in *Città e Storia, VI,* no.1, Rome: Università Roma Tre-CROMA, pp. 207-237.

CIRANNA, S., FELLI, M. (2018), *Ingegneria e Architettura lungo un secolo di storia. Lo studio degli ingegneri Inverardi dell'Aquila,* in D'AGOSTINO, S., et al., ed., *History of Engineering. Storia dell'Ingegneria. Proceedings of the 3rd International Conference. Atti del 7° Convegno Nazionale,* volume I, Naples: Cuzzolin

CIRANNA, S., MONTUORI, P. (2014) a, *Avezzano 1915. Conoscere e riconoscere una nuova identità,* in BUCCARO A., DE SETA C., ed., *Città mediterranee in trasformazione. Identità e immagine del paesaggio urbano tra Sette e Novecento. Atti del VI Convegno Internazionale di Studi Centro di Ricerca sull'Iconografia della Città Europea,* Naples: Edizioni Scientifiche Italiane.

CLEMENTI, A., COLAPIETRA, R. (1979), *Antinoriana. Studi per il bicentenario della morte di Antonio Ludovico Antinori. Pubblicati dalla Deputazione Abruzzese di Storia Patria,* L'Aquila: Edizioni Libreria Colacchi (anast. ed. 2002).

COLAPIETRA, R. (1979), *Itinerario storico abruzzese,* Lanciano.

COLAPIETRA, R., CENTOFANTI, M., BARTOLOMUCCI, C., AMEDORO, T. (1997), *L'Aquila: i palazzi*, L'Aquila, Ediarte.

COLAPIETRA, R., CENTOFANTI., M (2009), *Aquila: dalla Fondazione alla renovatio Urbis,* L'Aquila: Textus.

COLLEPARDI, M., COLLEPARDI, S., TROLLI, R. (2014), *Il nuovo calcestruzzo,* Villorba: Tintoretto

CONNALLY, E. A. (1964), *Texas Architecture,* in *Historic Preservation,* November-December.

CONTI, A (1973), *Storia del restauro,* Milano: Electa.

CORBETT, E. J., JOHNSON, C. E. (1982), *The Santa Barbara, California, Earthquake of 13 August 1978,* in *Bulletin of the Seismological Society of America,* Vol. 72, No. 6, December, pp. 2201-2226.

CORSIGNANI, P. (1738), *Reggia Marsicana*, Bologna: Forni Editore (anast. ed. 1971).

CORTESI, F., LUDOVISI, L, MARIANI, V. (2020), *La progettazione strutturale su edifici esistenti,* Santarcangelo di Romagna: Maggioli Editore.

CRESPI, P., FRANCHI, A., GIORDANO, N., RONCA, P., SCAMARDO, M. (2015), *The basilica of Collemaggio in L'Aquila: seismic assessment analysis,* in BARROS, H., LOJA, A., FERREIRA, C., BARBOSA, J. I., ADAM, J. M., FRAGIACOMO, M., MARI., A. R., ed., *International Conference on Recent Advances in Rehabilitation and Sustainability of Structures. RehabStructures*.

CROCI, G. (2012), *Conservazione e restauro strutturale dei beni architettonici,* Turin: Utet.

CUSTANCE-BAKER, A., MACDONALD, S. (2015), *Conserving Concrete Heritage Experts Meeting,* Los Angeles: Paul Getty Trust.

D'ALBERTO, C. (2011), ed., *Prima e dopo il sisma. Vicende conservative dell'arte medieval in Abruzzo*, Teramo: Edizioni D'Errico.

D'ANTONIO, M. (2003), *Abbazie benedettine in Abruzzo,* Pescara: Carsa.

D'ANTONIO, M. (2013), *Ita terremotus damna impedire. Note sulle tecniche antisismiche storiche in Abruzzo,* Pescara: Carsa Edizioni.

DE NINO, A. (1904), *Sommario dei monumenti e degli oggetti d'arte. Descritti da Antonio De Nino*, Vasto: L. Anelli.

DE' GUIDOBALDI, D. (1908), *Decreto de' Cultori di Ercole per la celebrazione del natale di T. Claudio Imeo nel tempio di Ercole in Vico Stramento ora S. Maria a Vico nel territorio di Sant'Omero*, in DE BERARDINIS, D. ed., *La Valle Vibrata nella storia e nell'arte*, Senigallia.

DEL BUFALO, A., CONTINI, G.B. (1982), *Contini e la tradizione del tardomanierismo nell'architettura tra '600 e '700*, Rome: Ed. Kappa.

DI BIASE, C. (2015), *Durata e durabilità del calcestruzzo storico nell'architettura del XX secolo,* in *Materiali e Strutture. Problemi di conservazione. La materia del restauro,* Nuova Serie, IV, no.8, Sapienza University of Rome, pp. 43-64.

DI CRISTOFANO, E., (2016), *I danni al patrimonio artistico di Avezzano a seguito del terremoto del 1915*, in *100 anni terremoto Avezzano. Atti delle conferenze per il centenario del terremoto del 13 gennaio 1915*, Cerchio-Avezzano: Edizioni Kirke.

DI CRISTOFANO, E., TANGREDI, A. (2015), *Magliano De' Marsi. 13 gennaio 1915. Storia di un sisma, tra vita quotidiana, arte e solidarietà*, Cerchio-Avezzano: Edizioni Kirke.

DI DOMENICO, R. (2002), *Il castello Orsini-Colonna*, Avezzano: Amministrazione comunale.

DI FLORIO, V. (2015), *Il municipio di Celano: un'esperienza di rilettura dell'identità urbana,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

DI PIETRO, A., (1869), *Agglomerazioni delle popolazioni attuali della Diocesi dei Marsi*, Avezzano: Tipografia Marsicana di Vincenzo Magagnini.

DOLCE, M., MORONI, C. (2013), *Il terremoto dell'Aquila,* in MARCHETTI, L., ALTORIO, E., ed., *MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009,* Avezzano: Officina Multimedia Abruzzo.

DOMENICI, G., GAGLIARDI, R. (1996), *Chiese monumentali dell'arcidiocesi di Ancona*, Ancona: Aniballi.

DONA', C. (2009), *Sicurezza strutturale e conservazione del costruito storico: alla ricerca di una reciproca conciliabilità,* in *Atti del XIII Convegno Nazionale ANIDIS, L'ingegneria sismica in Italia.*

DONATELLI, A. (2010), *Terremoto e architettura storica. Prevenire l'emergenza,* Rome: Gangemi.

DONATELLI, A. (2016), *'Ortodossia' teorica e 'eresia' operativa in alcuni consolidamenti del Ventennio fra Roma e Lazio,* in in DRIUSSI, G., BISCONTIN, G., ed., *Eresia ed Ortodossia nel Restauro. Progetti e realizzazioni,* Scienza e Beni Culturali, Edizioni Arcadia Ricerche.

DONGHI D. (1909-1935), *Manuale dell'architetto, compilato sulla traccia del Baukunde des Architekten da Daniele Donghi*, Turin: Utet.

DORANTE, M. A. (1999), *La cattedrale di Teramo: i restauri e le trasformazioni dal Cinquecento ai giorni nostri,* in *Opus. Quaderno di storia dell'architettura e restauro,* no. 6, pp. 377-386.

EBERHARDT, J. (1994), *Das Kastel von L'Aquila - Il Castello di L'Aquila*, translated by MUCCIANTE, G., L'Aquila.

ECKEL, D. C. (1913), *Portland Cement Materials and Industry in the United States,* Washington: Government Priting Office.

EUGENI, F. (1998), ed., *Il Duomo di Teramo: rassegna stampa (1886-1968),* in *Il Duomo di Teramo nel '900, tra forma urbana e società civile,* Teramo: Deltagrafica

FANCELLI, P. (1979), *L'unità metodologica del restauro*, in *Storia architettura, n.2-3*.

FEBONIO, M. (1678), *Historiae Marsorum Libri Tres,* Napoli: Michele Monaco, L'Aquila: Fondazione Cassa di Risparmio della Provincia dell'Aquila (anast. Ed. 2012).

FELLI, M. (2018), *Il ruolo innovativo di Ignazio Gavini nei restauri abruzzesi di inizio Novecento. The Innovative Role of Ignazio Gavini in Restoration Works in Abruzzo at the Beginning of the Twentieth Century,* in PORCINARI, D., ed., *XIV Congresso internazionale di riabilitazione del patrimonio. La conservazione del patrimonio architettonico, archeologico e paesaggistico*¸ Naples: Luciano Editore

FIENGO, G. (1973), *Restauri d'Abruzzo,* in *Restauro,* II, no.9, pp. 79-84.

FILIPOVIC, A., TROIANO, W. (2013), ed., *Strategie e Programmazione della Conservazione e Trasmissibilità del Patrimonio Culturale,* Roma: Edizioni Scientifiche Fidei Signa.

FIORANI, D. (1994), *Lo studio delle tecniche costruttive murarie antiche: orientamenti, problemi, acquisizioni,* in *Palladio,* no.14, July-December, pp. 101-108.

FIORANI, D. (2007), *Rovine e miracoli artistici del terremoto di Avezzano: le architetture storiche nella piana del Fucino,* in SETTE, M. P., ed. *Saggi in onore di Gaetano Miarelli Mariani,* Quaderni dell'Istituto di Storia dell'Architettura, Rome: Bonsignori Editore.

FIORANI, D. (2009), *Edifici storici, stratificazioni e danni nell'aquilano, una panoramica,* in *Arkos. Scienza e Restauro,* 20, July/September.

FIORANI, D. (2011), *Il perenne ciclo del divenire nel cantiere storico aquilano. Annotazioni su tessuto urbano, architetture e costruzione nella città dei terremoti,* in *Città e Storia,* VI, pp. 239-260.

FIORANI, D., MUSSO, S. F. (2016), *Il restauro fra opposti paradigmi e necessità di cambiamento,* in DRIUSSI, G., BISCONTIN, G., ed., *Eresia ed Ortodossia nel Restauro. Progetti e realizzazioni,* Scienza e Beni Culturali, Edizioni Arcadia Ricerche.

FORBES, A. (1937), *A History of Upper and Lower California,* San Francisco: John Henry Nash (anast. ed. 1972).

FRANCHI VICERE', L., VIGGIANI, C., SQUEGLIA, N. (2005), *La salvaguardia della torre: studi e interventi eseguiti prima del 1990,* in SETTIS, S., ed., *La torre restituita. Gli studi e gli interventi che hanno consentito la stabilizzazione della torre di Pisa,* in *Bollettino d'arte, volume speciale*.

FUCINESE, D. V. (1978), *Storiografia e restauro architettonico in Abruzzo,* Rome: Multigrafica.

FUCINESE, D.V. (1974), *Gli interventi nella cattedrale di Valva (1680-1971),* in *Quaderni del Museo Civico di Sulmona*.

FUCINESE, D.V. (1980) a, *Appunti su due facciate settecentesche a Sulmona. L'Annunziata e S. Spirito del Morrone*, in *Atti XIX C.*

GALADINI, F., VARAGNOLI, C., (2006), *Marsica 1915 - L'Aquila 2009. Un secolo di ricostruzioni,* Roma: Gangemi Editore.

GAVINI, I. C. (1915) a, *I terremoti d'Abruzzo e i suoi monumenti*, in *Rassegna Abruzzese di Scienze, Lettere ed Arti,* XXX, pp. 235-240.

GAVINI, I. C. (1915) b, *Studi sull'architettura d'Abruzzo. La scuola di San Liberatore alla Maiella*, in, *Rassegna d'Arte degli Abruzzi e del Molise*, *a. IV*, no. 1-4.

GAVINI, I. C. (1917), *La cattedrale valvense e l'attuale restauro,* in *Rassegna D'Arte,* September-October, Milan: Editori Alfieri & Lacroix

GAVINI, I. C. (1922), *Il restauro della chiesa di Santa Maria delle Grazie in Luco De' Marsi,* in *Bollettino d'Arte del Ministero della Pubblica Istruzione,* July, Milan-Rome: Casa Editrice D'Arte Bestetti & Tumminelli.

GAVINI, I. C. (1923), *Il cemento armato nel restauro dei monumenti,* in *Ingegneria. Rivista Tecnica Mensile,* February 1st, no. 2, Milan: Stab. Tip.-Lit. Stucchi Ceretti (Soc. An.).

GAVINI, I. C. (1927) a, *Guida ai monumenti storici e artistici della Marsica,* Cerchio: Adelmo Polla (anast. Ed.2000)

GAVINI, I. C. (1927-28) b, *Storia dell'Architettura in Abruzzo,* Milan Rome: Bestetti e Tumminelli.

GEMINIANI, F. (2015), *La basilica dei Santi Cesidio e Rufino a Trasacco: ricerca della perduta identità architettonica attraverso una lettura storico-critica,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

GIAMPIERO, D. (1896), *Descrizione dei principali monumenti antichi della provincia di Teramo*, in *Monografia della provincia di Teramo*, Teramo: Fabbri.

GIANNANTONIO, R. (2004), *Architettura moderna nell'Abruzzo del Fascismo,* in TIBONI, E., RUSSO, ed., *L'Abruzzo nel Novecento,* Pescara: Ediars.

GIFFORDS, G. F. (2007), *Sanctuaries of Earth, Stone, and Light*, Tucson: The University of Arizona Press.

GIOVANNONI, G. (1913), *Restauri di monumenti Conferenza di Gustavo Giovannoni,* in *Bollettino D'Arte VII,* I-II, January, February.

GIOVANNONI, G. (1917) a, *Per la ricostruzione di città e borgate distrutte,* in *La nuova Antologia,* pp. 156-165.

GIOVANNONI, G. (1917) b, *Per le costruzioni nei paesi del terremoto marsicano,* in *Annali d'Ingegneria e d'Architettura,* Rome: Tipo-Litografia del genio Civile.

GIOVANNONI, G. (1924), *Cronaca dei monumenti, in Architettura e arti decorative*, *a.III* (1923-1924), no. 5.

GIOVANNONI, G. (1929), *Questioni di architettura nella storia e nella vita. Edilizia-Estetica architettonica–Restauri–Ambiente dei monumenti,* Rome: Biblioteca d'Arte Editrice.

GIOVANNONI, G. (1931), *Sull'applicazione dei mezzi costruttivi moderni ed in particolare del cemento armato, nel restauro dei monumenti*, in *L'Industria Italiana del Cemento III* (12), pp. 363–367.

GIOVANNONI, G. (1932), *La conferenza di Atene per il restauro dei monumenti*, in *Bollettino d'Arte,* March, pp. 408–420.

GIOVANNONI, G. (1933), *La restauration des munuments en Itale*, in *La Conservation des Monuments d'Art e d'Histoire*, Paris: Institut de Coopération Intellectuelle, 60–66.

GIOVANNONI, G. (1945), *Architetture di pensiero e pensieri sull'architettura,* Rome: Apollon.

GIOVANNONI, G. (1946), *Il Restauro dei monumenti*. Rome

GIUFFRÉ, A. (1988), *Monumenti e terremoti, aspetti statici del restauro,* Rome.

GIZZI, S. (1988), *Le reintegrazioni nel restauro: una verifica nell'Abruzzo Aquilano*, Rome: Kappa.

GRASSI, L. (1959), *Camillo Boito*, Milano: Il Balcone

GUARISCO, G., ACITO, M., CUSATELLI, S., RAJABI, M. (2019), *Camillo Boito's "Capannone" for the Accademia di Brera in Milan: Reuse of a Railway Depot*, in DELLA TORRE, S., BOCCIARELLI, M., DAGLIO, L., NERI, R., ed., *Buildings for Education. Research for Development*. Springer, Cham

GUBLER, J. (1992), *Le bellezze del cemento armato,* in *Rassegna, 49*, pp. 84-88.

HITCHCOCK, H. R. (1968), *Ruskin and American Architecture. Converning Architecture*, London: Allen Lan The Penguin Press.

HOLLERS GEORGE, M. C. (1972), *Alfred Giles: An English Architect in Texas and Mexico,* San Antonio: Trinity University Press.

HOLLERS GEORGE, M. C. (2006), *The Architectural Legacy of Alfred Giles. Selected Restoration,* San Antonio TX: Trinity University Press.

HOLLERS JUTSON, M. C., LAWRIE, J. S. (1974), *Alfred Giles. An English Architect in Texas and Mexico*, in *Journal of the Society of Architectural Historians*, vol.33 no;2, May.

HOUSNER, G. W., JENNINGS, P. C. (1977), *Earthquake Design Criteria for Structures,* Pasadena California: California Institute of Technology.

HUCKINS, P. J. (2011), *Art in the Alta California Mission Churches, 1769 – ca. 1834,* PhD Dissertation, Department of Fine Arts, New York University.

HUME, G. L. (1986), *The Development of the Secretary of the Interior's Standards,* in *Preservation News,* National Trust for Historic Preservation.

IAFELICE, C. (2014), *Sebastianus Majewski pittore polacco nell'Abruzzo del XVII secolo e l'altare di San Berardo nella cattedrale di Teramo,* in *Il Capitale Culturale. Studies on the Value of Cultural Heritage, 10,* Journal of the Section of Cultural Heritage, University of Macerata: eum edizioni università di macerata.

IENTILE, R. (2008), ed., *Architetture in cemento armato. Orientamenti per la conservazione,* Milan: FrancoAngeli.

JACKSON, H. H. (1884), *Ramona,* New York: Harper Collins (anast. ed. 1976).

JACKSON, M. L. (2004), *The Principles of Preservation: The Influence of Viollet, Ruskin and Morris on Historic Preservation,* Thesis in Bachelor of Arts, Southwestern Oklahoma State University, Weatherford.

JAMES, G. W., *The old Franciscan missions of California, 1858-1923.*

JETTI, G. (1978), *Cronache della Marsica (1799-1915),* Naples: Luigi Regina Editore.

JETTI, G. (2016), *Avezzano e il prosciugamento del Fucino*, Cerchio-Avezzano, Edizioni Kirke.

JETTI, R., (1912), *Castelli d'Abruzzo. Rocche marsicane*, in *Il Secolo XX*, December 12th.

KESSEL, J. L. (2002), *Spain in the Southwest: A Narrative History of Colonial New Mexico, Arizona, Texas, and California*, Norman: University of Oklahoma Press.

LAGOMARSINO, S. (2004) a, *Seismic vulnerability of ancient churches, Part 1: damage assessment and emergency planning,* in *Earthquake Spectra,* vol. 20, pp. 337-394.

LAGOMARSINO, S. (2004) b, *Seismic vulnerability of ancient churches, Part 2: damage assessment and emergency planning,* in *Earthquake Spectra,* vol. 20, pp. 395-412.

LAGOMARSINO, S. (2009), *Vulnerabilità e risposta sismica delle chiese aquiline: interpretazione del danno e considerazioni sul miglioramento strutturale,* in *Arkos. Scienza e Restauro,* 20, July/September.

LAGOMARSINO, S., CATTARI, S. (2013), *I criteri di messa in sicurezza degli edifici in muratura,* in MARCHETTI, L., ALTORIO, E., ed., *MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009,* Avezzano: Officina Multimedia Abruzzo.

LANGENBACH, R. (1989), *Bricks, Mortar and Earthquakes,* in *APT Bulletin* XXXI, No. 384.

LANZARONE, F., GARGAGLIANO, L., CUFFARO, M. (2010), *Progettare il recupero edilizio. Le patologie e gli interventi più frequenti nella manutenzione straordinaria degli edifici,* Palermo: Dario Flaccovio Editore.

LECKMANN BROKHAUS, O. (1968), *Gli amboni abruzzesi*, in *Abruzzo n.2-3.*

LEE, A. J. (1990), *Spanish Missions,* in *The Journal of Preservation Technology. ATP Bulletin,* n. 3.

LEON, P. (1917), *Les monuments historiques. Conservation. Restauration*, in *Journal des Savants,* Année 1917, 8, pp. 337-350

LEOSINI, A. (1974), *Monumenti storici artistici della città di Aquila e i suoi contorni,* Bologna: Forni.

LOPEZ, L. (1974), *L'Aquila nella storia e nell'arte,* Teramo: Tazzi.

LOPEZ, L. (1988), *L'Aquila. Le memorie, i monumenti, il dialetto*, L'Aquila.

LOS ANGELES CITY COUNCIL, (1933), Ordinance No. 72968, *Riley Act for building constructions*, Los Angeles.

LUCIBELLO, G. (2014), *Capacità sismica di edifici monumentali in muratura,* PhD Dissertation in Civil Systems Engineering, Naples: University Federico II.

LUSTRI, S. (1988), *Avezzano sparita*, Rome: Legraf.

MAESTRI, D., CENTOFANTI, M., DENTONI LITTA, A. (1992), *Immagini di un territorio: l'Abruzzo nella cartografia storica: 1550-1850,* Regione Abruzzo.

MANCIINI, R., FRANCHI, R. (1986), *Quattro monumenti da salvare*, Lanciano: Ed. Intinerari.

MANCINI, R. (1982), *Architettura minore in Abruzzo,* in *Rassegna di studi sul territorio. Comunità montana sirentina, I, 1*, pp. 41-53.

MANCINI, R. (1986), *Conoscere l'arte e i monumenti d'Abruzzo*, L'Aquila: Edizioni del Gallo Cedrone.

MANCINI, R. (2004) a, *Viaggiare negli Abruzzi. Una terra da scoprire attraverso le sue vie storiche. Ambiente, archeologia, arte, monumenti. Volume Primo: la Via Valeria I: il Carseolano e i Piani Palentini,* L'Aquila: Textus.

MANCINI, R. (2004) b, *Viaggiare negli Abruzzi. Una terra da scoprire attraverso le sue vie storiche. Ambiente, archeologia, arte, monumenti. Volume Secondo: la Via Valeria II: il Fucino, la Valle Roveto, l'Altopiano delle Rocche, il Parco nazionale d'Abruzzo, la Valle Peligna,* L'Aquila: Textus.

MANCINI, R. (2004) c, *Viaggiare negli Abruzzi. Una terra da scoprire attraverso le sue vie storiche. Ambiente, archeologia, arte, monumenti. Volume Terzo: la Via Valeria III: le sorgenti del Pescara, la Valle dell'Orta, Casauria, la Valle del Pescara, Alano e gli albanesi, la Majella Pescarese, Chieti, Penne e il pennese, Pescara,* L'Aquila: Textus.

MANZO, L. (2014), *Esplorando tra le carte. La Mole Antonelliana,* Turin: Città di Torino.

MARCHETTI, L. (2013), *La messa in sicurezza degli edifici religiosi,* in MARCHETTI, L., ALTORIO, E., ed., *MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009,* Avezzano: Officina Multimedia Abruzzo.

MARCHETTI, L., ALTORIO, E. (2013), ed., *MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009,* Avezzano: Officina Multimedia Abruzzo.

MARCHETTI, L., MILANO, L., MORISI, C., CALDERINI, C., DONATELLI, A. (2011), *L'università e la ricerca per l'Abruzzo. Il patrimonio culturale dopo il terremoto del 6 aprile 2009,* L'Aquila: Textus.

MASSA, M. (1993), *Le prime identità del XIII secolo: Magister Philippus e gli altri*, in ZAMPETTI, P., ed., *Scultura nelle Marche*, Firenze, Nardini. p. 155.

MASTRODDI, M. (2005), *L'altra Avezzano,* Avezzano: Comune di Avezzano.

MATTHIAE, G. (1935), *Le facciate a coronamento rettilineo in Abruzzo*, in Bollettino della Deputazione di Storia Patria.

MAYS, G. (1992), ed., *Durability of Concrete Structure. Investigation, repair, protection,* London: Spon Press.

MCCALEB, W. F. (1961), *Spanish Missions of Texas.* San Antonio, Texas: The Naylor Company.

MEISTER, C. (2004), *Alfred Giles vs El Paso County: An Architect Defends His Reputation on the Texas Frontier,* in *The Southwestern Historical Quarterly,* Vol 108 No 2 (October), Texas State Historical Association.

MIARELLI MARIANI, G. (1979), *Monumenti nel tempo. Per una storia del restauro in Abruzzo e nel Molise,* Rome: Carucci Editore.

MINISTERO DELLA PUBBLICA ISTRUZIONE (1902), *Elenco degli Edifici Monumentali in Italia,* Rome: Tipografia Ditta Ludovico Cecchini.

MINISTERO DELLA PUBBLICA ISTRUZIONE (1950), *La ricostruzione del patrimonio artistico italiano,* Rome: La Libreria dello Stato.

MONTGOMERY, R. (1925), *Restoration of the Santa Barbara Mission,* in *Bulletin of the Seismological Society of America,* 15 (4), pp. 305-307

MONTUORI, P. (2015) a, *Avezzano città asismica: "un altro volo nel quale l'antico si rischiara",* in CIRANNA, S., MONTUORI, P., *Tempo, spazio e architetture. Avezzano cento anni o poco più,* Rome: Artemide.

MONTUORI, P. (2015) b, *L'impiego "giudizioso" del cemento armato dopo il sisma della Marsica del 1915. La ricostruzione della chiesa di San Giovanni Decollato in San Francesco ad Avezzano*, in DE CESARIS, F., ed., *Costruzioni dei secoli XIX-XX in Italia centrale. Architettura, scienza, tecniche di restauro,* Rome: Palombi Editori.

MONTUORI, P. (2016), *L'Alba senza tramonto. Alba Fucens antica, medievale, moderna: un palinsesto storico-architettonico e paesaggistico. Dawn without sunset: ancient, medieval and modern Alba Fucens – an architectural-historical and landscape palimpsest,* in CAPANO, F., PASCARIELLO, M. I., VISONE, M., ed., *Delli Aspetti di Paesi. Vecchi e nuovi Media per l'Immagine del Paesaggio. Old and New Media for the Image of the Landscape,* Naples: CIRICE.

MORETTI, M. (1972) b, *Architettura medioevale in Abruzzo, dal VI al XVI secolo*, Gaeta; De Luca Editore.

MORETTI, M. (1972) d, *Decorazione scultoreo-architettonica altomedievale in Abruzzo,* Rome: De Luca Editore.

MORRISON, H. S. (1952), *Early American Architecture, From the First Colonial Settlements to the National Period,* New York: Oxford University Press.

MUNOZ, A. (1915), *I monumenti del Lazio e degli Abruzzi danneggiati dal terremoto,* in *Bollettino d'arte, II-IV,* February-April.

MUNOZ, A. (1916), *Monumenti d'Abruzzo. Cittaducale,* Rome: Calzone Editore

MUSMECI, S. (1980), *Struttura ed architettura,* in *L'Industria Italiana del Cemento*

NARDECCHIA, P. (2004), *Note d'arte abruzzese tra la Marsica e il Carseolano*, Rome: Lumen.

NATALUCCI, M. (1961), *La vita millenaria di Ancona*, Ancona.

NERVI, P. (1945), *Scienza o arte del costruire? Caratteristiche e possibilità del cemento armato,* Rome: Edizioni della Bussola.

NEUERBURG, N. (1987), *The Decoration of the California Missions,* Santa Barbara California: Bellerophon Books.

NOEL HUME, I. (1970), *A Guide to Artifacts of Colonial America,* New York: Knopf.

OSIO, A.M. (1996), *The History of Alta California: A Memoir of Mexican California,* translated and ed. BEEBE, R.M., SENKEWICX, R.M., Madison: University of Wisconsin Press.

PACE, V. (1971), *Ancora sulla tutela del patrimonio artistico. Restauri ai monumenti dell'Abruzzo*, in *Paragone*, no. .261.

PACE, V., THIELEMANN A., ANDALORO, M., ACETO, F., TARANTELLI, P., CIRANNA, S., et al. (2010), *Il terremoto del 6 aprile 2009 in Abruzzo: danni, interventi, iniziative e schede. La terra trema: storia e attualità dei sismi in Abruzzo,* in *Kunst Chronik 63,* no. 2, February, pp. 45-67.

PADDISON, J. (1999), ed., *A World Transformed: Firsthand Accounts of California Before the Gold Rush*. Berkeley, CA: Heyday Books.

PALMIERI, E. (2006), *Avezzano, un secolo di immagini,* Pescara: Editore Paolo Da Siena.

PANE, R. (1950) a, *Il restauro dei monumenti,* in MINISTERO DELLA PUBBLICA ISTRUZIONE, *La ricostruzione del patrimonio artistico italiano,* Rome: La Libreria dello Stato.

PANE, R. (1950) b, *Il restauro dei monumenti. Prefazione,* in MINISTERO DELLA PUBBLICA ISTRUZIONE, *La ricostruzione del patrimonio artistico italiano,* Rome: La Libreria dello Stato.

PANSA, G. (1893), *Il Chronicon Casauriense e le vicende dell'insigne monastero benedettino,* Lanciano: Rocco Carabba Editore.

PAPINI, R. (1915), *I monumenti danneggiati nelle regioni limitrofe al Lazio ed all'Abruzzo,* in *Bollettino d'arte, II-IV,* February-April.

PEROGALLI, C. (1975), *Castelli dell'Abruzzo e del Molise,* Milan: Gorlich Ed.

PESIRI, G., PROCACCIA, M., TASCINI, I. P., VALLONE, L. (1991), ed., *Archivi di famiglie e di persone. Materiali per una guida,* Ministero per I Beni Culturali e Ambientali, Ufficio Centrale per I Beni Archivistici: Pubblicazioni degli Archivi di Stato.

PETITE, M. D. (1999). *1836 Facts about the Alamo and the Texas War for Independence.* Mason City, IA: Savas Publishing Company.

PEZZI, A. G. (2000), *Storiografia, restauro e progetto nell'opera di Ignazio Carlo Gavini,* in CITIVA, M., VARAGNOLI, C., ed., *Identità e Stile. Monumenti, città, restauri tra Ottocento e Novecento,* Rome: Gangemi, pp. 211-244.

PEZZI, A. G. (2003), *Tutela e restauro in Abruzzo dall'Unità d'Italia alla Seconda Guerra Mondiale (1860-1940). Istituzioni, interventi, metodi*, PhD Dissertation in History of Architecture, Chieti: University "G. D'Annunzio".

PEZZI, A. G. (2005), *Tutela e restauro in Abruzzo. Dall'Unità alla seconda guerra mondiale: 1860-1940,* Rome: Gangemi

PICCIRILLI, P. (1804), *La Marsica. Appunti di Storia e d'Arte,* I, Trani, V. Vecchi.

PICCIRILLI, P. (1886), *La chiesa e il Palazzo dell'Annunziata a Sulmona*, in *L'Italia artistica illustrata*, no.10.

PICCIRILLI, P. (1888) a, *La gradinata dell'Annunziata di Sulmona*, in *Il Pallano*, October 28th.

PICCIRILLI, P. (1888) b, *Monumenti architettonici sulmonesi, Tipografia dello stabilimento*, Lanciano: R. Carabba.

PICCIRILLI, P. (1894), *Notizie storiche e artistiche di Alba Fucense*, in *Rivista abruzzese di storia, letteratura e arti*.

PICCIRILLI, P. (1897), *Monumenti da restaurare. Palazzo della SS Annunziata*, in *Rivista abruzzese di storia, letteratura e arti*, no.2. RASLA

PICCIRILLI, P. (1900), *L'Abruzzo monumentale*, in *Rassegna abruzzese di storia e di arte,* no. 10.

PICCIRILLI, P. (1902), *Monumenti marsicani. Ortucchio e alcune opere di artisti sulmonesi del secolo XV*, Trani.

PICCIRILLI, P. (1916), *Su e giù per l'Abruzzo*, in *Pagine d'arte*, no.12.

PICCIRILLI, P. (1917, *Restauri di monumenti danneggiati dal terremoto del 1915,* in *Pagine d'arte, V*, January, pp. 184-186

PICCIRILLI, P. (1919), *Monumenti Abruzzesi. Il Palazzo della SS Annunziata in Sulmona*, in *Rassegna d'arte*, no.7-8.

PINO, N. A., PIATANESI, AL., VALENSISE, G., BOSCHI, E. (2009), *The 28 December 1908 Messina Straits Earthquake (MW 7.1): A Great Earthquake throughout a Century of Seismology,* in *Seismological Research Letters,* n. 80 (2), pp. 243-259, Geoscience World.

PIRANI, E. (1987), *Memorie dell'Accademia Marchigiana di Scienze Lettere ed Arti,* Ancona.

PIVA, P. (2003), *Marche Romaniche*, D'Auria editrice, Editoriale Jaka Book.

POGGI, G. (1914), *Arte medievale negli Abruzzi. Architettura e scultura*, Milan: Casa Editrice Meiss.

PRETA, L. (1915), *Storia delle missioni Francescane in California con illustrazioni.*

R. SOPRINTENDENZA ai Monumenti di Roma e degli Abruzzi (1915), *I danni dell'arte nei paesi battuti dal terremoto del 13 gennaio 1915,* in *Bollettino d'Arte,* II, Supplemento n. 1.

RADKE, G. M. (1996), *Viterbo. Profile of a Thirteenth-Century Papal Palace*, Cambridge (Mass.), pp. 248-266.

RE, L. (2003), *The work of Alessandro Antonelli and Crescentino Caselli between the Architecture of the Raison and the architecture raisonnée,* in HUERTA, S., JUAN DE HERRERA, I., BENVENUTO, A. E., DRAGAOS, F., ed., *Proceedings of the First International Congress on Construction History, Madrid.*

REDI, F., ARMILLOTTA, F. (2015), ed., *Restaurare in Abruzzo. Formazione e nuove professionalità per l'analisi e la conservazione dell'edilizia storica,* Pescara: Carsa.

REGGIANI, A. M. (2011), *Il patrimonio ferito dell'Aquila. Damaged Heritage Buildings at L'Aquila,* in *ROMVIA, Reviste del Seminario de Arqueologia de la Universidad Pablo de Olavide de Sevilla,* 10, pp. 307-342.

ROBERTS, R., OLSON, J. S. (2001), *A Line in the Sand: The Alamo in Blood and Memory*, The Free Press.

ROSS, E. (2006), *The Franciscan Mission to the Navajos: Mission Method and Indigenous Religion, 1898-1940*.

ROSS, Ma. (1926), *The restoration of the Spanish missions in Georgia,* in *The Georgia Historical Quarterly*, vol. 10, no. 3 (September), pp. 171-199.

RUSCIN, T. (1999), *Mission Memories*. San Diego California: Sunbelt Publications.

SABATINI, F. (1993), ed., *L'Aquila e la provincia aquilana. Economia, società e cultura dal 1859 al 1920,* L'Aquila: Cassa di Risparmio della provincia dell'Aquila Spa.

SABATINI, G. (1960), *Saggio bibliografico di mappe e panorami d'Abruzzo*, in *Bollettino della Deputazione Abruzzese di Storia Patria*, 1957-1960

SACCONI, G. (1902), *Relazione dell'Ufficio Regionale per la conservazione dei Monumenti delle Marche e dell'Umbria (1891-1901),* Perugia: Guerra.

SALADINO, L. (2000), *I monumenti benedettini nell'Abruzzo interno. Insediamenti, infrastrutture e territorio tra VIII e XI secolo,* Rome: Palombi.

SALAZARO, D. (1881), *Studi sui monumenti dell'Italia Meridionale dal IV al XII secolo per D.S.,* Naples.

SALVONI SAVORINI, G. (1933), *Contributi alla storia artistica della cattedrale teramana,* in *Teramo,* no.2.

SANCHEZ, G., FAIA, ALLEN, D. (1989), *Seismic strengthening of historic adobe buildings in California: an overview*, in *Seismic Mitigation. The Getty Adobe Research Project at Fort Selden,* Marina del Rey California: Getty Conservation Institute.

SARA', G. (1989), ed., *Restauro strutturale,* Naples: Liguori Editore.

SCHULZ, H. W. (1860), *Denkmaeler der Kunst des Mitterlalter in Unteritalien von H.W.S., Nach dem Tode des Verfassers herausgegenben von F. von Quast*, Dresden.

SCONCI, E. (1983), *Il centro storico dell'Aquila, struttura urbana e modelli di rappresentazione*, L'Aquila: Marcello Ferri Editore.

SERAFINI, L. (2008), *Danni di guerra e danni di pace: ricostruzione e città storiche in Abruzzo nel secondo dopoguerra,* Villamagna: Casa Editrice Tinari.

SERRA, L. (1929), *Restauri e scoperte in Santa Maria della Piazza in Ancona*, in *Bollettino d'Arte IX*.

SGATTONI, G. (1975), *Un attentato all'arte abruzzese, il crollo di Santa Maria a Vico*, in *Il Messaggero (cronaca di Teramo),* April 14th.

SGATTONI, M. (1980), *Ultime scoperte a Santa Maria a Vico,* in *Atti XIX C.*

SORRICCHIO, L. (1915), *Da Atri,* in *Arte e storia*, no.3, Rome.

SPAGNESI, G., PROPERZI, P. (1972), *L'Aquila. Problemi di forma e storia della città,* Bari: Dedalo Libri.

SPREGA, A. (1902), *Relazione dei lavori eseguiti dall'Ufficio nel quadriennio 1899-1902*, Forzani.

STAATS, H. P. (1929), *California Architecture in Santa Barbara,* Architectural Book Publishing.

STERN, J. (1995), *Romance of the Bells: The California Mission in Art,* Irvine California: The Irvine Museum.

STOCKEL, G. (1981), *La città dell'Aquila. Il centro storico tra il 1860 e il 1960,* L'Aquila: Edizioni del Gallo Cedrone.

TABOR LINENTHAL, E. (1988), *A Reservoir of Spiritual Power: Patriotic Faith at the Alamo in the Twentieth Century,* in *The Southwestern Historical Quarterly,* vol. 91, no.4 (April), pp. 509-531.

THOMPSON, F. (2005), *The Alamo*. Denton, TX: University of North Texas Press

THURBER, M. B. et al. (1984), *The Missions of San Antonio: a Historic Structures Report and Administrative History. Part IIII: Twentieth Century Restoration,* Santa Fe, NM: NPS Southwest Cultural Resources Center, December.

TIBONI, E., RUSSO, U. (2000), ed., *L'Abruzzo nel Settecento,* Pescara: Ediars.

TIBONI, E., RUSSO, U. (2002), ed., *L'Abruzzo: dall'umanesimo all'età barocca,* Pescara: Ediars.

TIBONI, E., RUSSO, U. (2004), ed., *L'Abruzzo nel Novecento,* Pescara: Ediars.

TOPPOZADA, T., BRANUM, D. (2004), *California earthquake history,* in *Annals of Geophysics*, vol. 47, no. 2/3, April/June.

TORALDO, F., RANALLI, M. T., DANTE, R., (2014) ed., *L'architettura sulla carta. Archivi di Architettura in Abruzzo,* Villamagna: Casa Editrice Tinari.

TORRACA, G. (1983), Interview in *Italia Nostra*, 222, pp. 27-28, from CARBONARA, G. (2017), *Il restauro fra conservazione e modificazione. Principi e problemi attuali,* in *Frequenze_conservazione/restauro,* Napoli: artstudiopaparo.

URBANI, G. (2000), *Intorno al restauro,* Milan: Skira.

VALERIO, V. (2015), *Marsica 1915: le istituzioni statali di tutela alla prova del terremoto,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

VALLUZZI, M. R. (2004), *Consolidamento e recupero delle murature,* in ROMEO, C. R., ed., *Collana Scientifica "Reficere",* Faenza: Gruppo Editoriale

VALTIERI, S. (2005), *I restauri della Loggia papale di Viterbo,* in DELLA COSTA M., CARBONARA, G., ed., *Memoria e restauro dell'Architettura*, *Saggi in onore di Salvatore Boscarino*, Milan: Ex Fabrica, Franco Angeli.

VARAGNOLI, C. (2000), *La città degli eruditi: restauri a Viterbo (1870-1945),* in CIVITA, M., VARAGNOLI, C., ed., *Identità e stile. Monumenti, città, restauri tra Ottocento e Novecento*, Collana "I Saggi di Opus", 8, pp. 117-126.

VARAGNOLI, C. (2007), *Il restauro in Abruzzo e Molise,* in *Ananke,* 50-51, pp. 270-281.

VARAGNOLI, C. (2008), *Costruzione e ricostruzione in Abruzzo. Albe vecchia e la Chiesa di San Nicola,* in ESPOSITO, D., ed., *Il reimpiego in architettura,* Rome: Bernard Jean Francois, Bernardi Philippe, Collection de l'Ecole francaise de Rome, pp. 469-485.

VARAGNOLI, C., PEZZI, A. G. (2004), *La cultura del restauro,* in TIBONI, E., RUSSO, U., ed., *L'Abruzzo nel Novecento,* Pescara: Ediars.

VARRASSO, A. (1993), *San Clemente a Casauria ad un secolo dalla dichiarazione di monumenti nazionale,* in *La Nuova Provincia di Pescara, III,* no 1, January-Febrary.

VENTURA, S. (1853), *Brevi notizie su la fondazione del Monistero di Casauria e della traslazione del corpo di S. Clemente in esso con una piccola digressione riguardante l'antichissima città d'Interpromio,* Chieti: Tip. Di Francesco Del Vecchio.

VERLENGIA, F. (1934), *I lavori di restauro nella badia di San Giovanni in Venere*, in *La Tribuna*, December 27th.

WEBB, W. P. (1952), ed., *The Handbook of Texas,* Austin: The Texas State Historical Association.

WEBER, D. J. (1992), *The Spanish Frontier in North America*. In *Yale Western Americana Series,* New Haven, CT: Yale University Press

WEEKES-WILSON, L. (1913), *Monograph on the Old Franciscan Mission,* Santa Barbara California: Pacific Coast Publishing Company.

WRIGHT, R. (1950). California's Missions. Hubert A. and Martha H. Lowman, Arroyo Grande, CA.

YENNE, B. (2004), *The Missions of California*, San Diego, CA: Thunder Bay Press.

YOUNG, S., LEVICK, M. (1988), *The Missions of California.* San Francisco, CA: Chronicle Books LLC.

ZEVI, B. (1997), *Storia e controstoria dell'architettura in Italia,* in *Grandi Tascabili Economici Newton,* Rome.

ZORZI, A. (1972), *Venezia scomparsa,* Milano: Mondadori.

Bibliography about Italian, American and International Laws

(1904), *The Building Code of the City of Cleveland, Ohio*.

(1909), *Regio Decreto 18 aprile 1909 n.193, portante norme tecniche ed igieniche obbligatorie per le riparazioni ricostruzioni e nuove costruzioni degli edifici pubblici e privati nei luoghi colpiti dal terremoto del 28 dicembre 1908 e da altri precedenti elencati nel R.D. 15 aprile 1909 e ne designa i Comuni.*

(1911), *The Building Code of Portland, Oregon.*

(2004), *Codice dei beni culturale e del paesaggio, ai sensi dell'articolo 10, Legge 6 luglio 2002, n. 137*.

(2008), *Linee guida per la valutazione e la riduzione del rischio sismico del patrimonio culturale con riferimento alle Norme tecniche per le costruzioni di cui al decreto del Ministero delle Infrastrutture e dei trasporti del 14 gennaio 2008*.

(2011), *Codice dei beni culturali e del paesaggio,* Aggiornamento ottobre 2011.

CONSIGLO SUPERIORE DEI LAVORI PUBBLICI (2018), *Norme Tecniche per le Costruzioni, 17 gennaio 2018 (NTC18)*

FIB – International Federation for Structural Concrete (2013), *fib Model Code for Concrete Structures,* Berlin: Ernst & Sohn, Verlag fur Architektur un technische Wissenschaften GmbH & Co. KG.

ICOMOS (1999), *Beton et Patrimonie, in* Cahier no.18.

ICOMOS (2000), *Declaration of Assisi.*

ICOMOS (2003), *Icomos Charter. Principles for the Analysis Conservation and Structural Restoration of Architectural Heritage*.

ICRI (International Concrete Repair Institute) (2012), *Guideline No. 320.3R-2012*.

INDUSTRIAL COMMISSION OF WISCONSIN (1915), Building Code.

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (1985), *Uniform Building Code. 1985 edition,* Whittier California.

MINISTERO DELLE INFRASTRUTTURE E DEI TRASPORTI (2008), *Nuove norme tecniche per le costruzioni,* Rome.

MINISTERO DELLE INFRASTRUTTURE E DEI TRASPORTI (2009), *Circolare n. 617 del 2 febbraio 2009. Istruzioni per l'Applicazione Nuove Norme Tecniche Costruzioni di cui al Decreto Ministeriale 14 gennaio 2008,* Rome.

MINISTERO PER I BENI E LE ATTIVITA' CULTURALI (2010), *Circolare n. 26. Linee guida per la valutazione e riduzione del rischio sismico del patrimonio culturale allineate alle nuove Norme Tecniche per le costruzioni (d.m. 14 gennaio 2008).*

OFFICE OF ADMINISTRATIVE HEARINGS, Department of General Services (1985), *State Historical Building Code, Title 24, Building Standards,* State of California: Department of General Services.

REDDERSEN, E. E. (1939), *Index summary of the New Chicago Building Code*.

REGIONE TOSCANA (2019), *Legge regionale 21 maggio 2019, n.24. Disposizioni in materia di prevenzione e diminuzione del rischio sismico. Modifiche alla l.r. 58/2009*, Bollettino ufficiale n. 25 del 29/05/2019.

REGIONE UMBRIA (1981), *Direttive tecniche ed esemplificazione delle metodologie di interventi per la riparazione ed il consolidamento degli edifici danneggiati da eventi sismici* (art. 38 L.R. 1/7/81 n. 34).

THE GETTY CONSERVATION INSTITUTE (1985), *Adobe Consolidation*, 1988-1995

THE NATIONAL BOARD OF FIRE UNDERWRITERS OF NEW YORK (1922), *Building Code: an ordinance providing for fire limits, and regulations governing the construction, alteration, equipment, repair or removal of buildings or structures*.

UNITED STATES CONGRESS (1966), *Public Law 89-655-OCT. 15. An act to establish a program for the preservation of additional historic properties throughout the Nation, and for other purposes,* United States Government Printing Office.

UNITED STATES DEPARTMENT OF THE INTERIOR, National Park Service, Preservation Assistance Division (1983), *The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings,* Washington D. C.

Specific Bibliography for the Italian Case Studies

(1908), *La ricostruzione del Campanile di Venezia e della Loggetta del Sansovino*, in *Bollettino d'Arte, VII,* July

(1912), *Le feste di Venezia: inaugurazione del Campanile,* in *Bollettino d'Arte, IV*, April

(1925), *Il duomo di Spoleto,* Spoleto: Unione tip. Nazzarena.

(1935), *La chiesa cattedrale di Chieti,* Chieti: Bonanni.

(1965), *Attività delle Soprintendenze. Umbria (Gallerie e Monumenti),* in *Bollettino d'arte, V serie, I-II, Gennaio-Febbraio,* 131.

(1969), *Il palazzo Benin casa in Ancona*, in *Quattro monumenti italiani*, Roma: Istituto nazionale delle assicurazioni, pp. 103-128.

(1973), *Restauri nelle Marche. Ricerche, studi e interventi per la conservazione e la valorizzazione dell'ambiente storico,* Ancona: Bugatti Editore.

(1974), *Comune di Ancona. Ristrutturazione del Centro Storico*, Ancona.

(1991), *La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo,* in *Collana "Quaderni Didattici", n. 10*.

(1996), *Il Romanico. Architettura. Scultura. Pittura,* Koln: Kunemann Verlagsgesellschaft.

(1997), *Teatro comunale già Della Fama o Condominiale / a cura del Servizio beni ed attività culturali del Comune di Gubbio*, Gubbio: Ph. Photo Studio.

(1999), *Ancona e la sua cattedrale, rappresentazioni grafiche nel tempo, catalogo della mostra omonima*, Ancona: Casa editrice Nuove Ricerche.

(2000), *Il Castello Piccolomini di Celano*, L'Aquila: Soprintendenza ai ambientali e architettonici artistici e storici per l'Abruzzo.

(2003), *Umbria. From the Italy Experts,* Milano: Touring Club of Italy.

(2014), *Palazzo Ferretti,* Ancona: Museo Archeologico Nazionale delle Marche.

(2017), *Collemaggio. Basilica ritrovata,* ENI, available at https://www.eni.com/docs/it_IT/eni-com/media/dossier/collemaggio/Brochure-Collemaggio.pdf

ALIMENTI, G. (2016), *L'antica via Lauretana. Itinerario "Sì corporale, come spirituale" da Roma a Loreto. Parte terza, il percorso marchigiano*, Loreto: EUM Edizioni Università di Macerata.

ALINARI, A. (1935), *L'antica chiesa di San Massimo cattedrale di Forcona*, in *Bollettino Deputazione di Storia Patria*, *ser. IV*

ANGELELLI, W. (2011), *Da Sovana a Montefiascone passando per Tuscania: modelli e circolazione di maestranze nella scultura architettonica del XII secolo,* in ANGELELLI, W., POMARICI, F., ed., *Forme e storia: scritti di arte medievale e moderna per Francesco Gandolfo,* Roma: Artemide.

ANGELONI, V. (2000), *Santa Maria in Valle Porclaneta. Storia, arte, leggende e tradizioni,* Avezzano: Sogeas.

ANSELMI, S. E., PRINCIPI, L. (2013), *Il museo d'arte sacra di Orte,* Civita Castellana: Centro studi patrimonio San Pietro in Tuscia.

ANTONACCI E., GATTULLI, V., MARTINELLI, A., VESTRONI, F. (2012), *La Basilica di S. Maria di Collemaggio in L'Aquila: prima e dopo il terremoto*, in MILANO, L., MORISI, C., CALDERINI, C., DONATELLI, A., ed., *L'Università e la Ricerca per l'Abruzzo: il patrimonio culturale dopo il terremoto del 06 aprile 2009*, L'Aquila: Textus Edizioni

ANTONACCI, E., BEOLCHINI, G. C., DI FABIO, F., GATTULLI, V. (2001), *The dynamic behavior of the Basilica S. Maria di Collemaggio,* in 2nd *International Congress on Studies in Ancient Structures, Instanbul, Turkey.*

ANTONACCI, E., GATTULLI, V., GRAZIOSI., F., LEPIDI, M., VESTRONI, F. (2013), *La basilica di Santa Maria di Collemaggio. La storia, le attività, il terremoto del 2009, gli studi per la ricostruzione,* in FILIPOVIC, A., TROIANO, W. (2013), ed., *Strategie e Programmazione della Conservazione e Trasmissibilità del Patrimonio Culturale,* Roma: Edizioni Scientifiche Fidei Signa.

ANTONACCI, E., GATTULLI, V., MARTINELLI, A., VESTRONI, F. (2010), *Il crollo del transetto della Basilica di Collemaggio: analisi di vulnerabilità e meccanismo di collasso,* in *Atti del workshop: Sicurezza e conservazione dei beni culturali colpiti da sisma: Strategie e tecniche di ricostruzione ad un anno dal terremoto abruzzese*.

APA, M. (2015), ed., *Città natura architettura e arte sacra: Diocesi di Terni, Narni,* Milano: Mondadori

ARCA PETRUCCI, M., UFFREDUZZI, T. (2006), ed., *Aree dismesse e sviluppo locale nella Provincia di Terni,* Terni: Provincia di Terni, Agenzia Umbria Ricerche.

AURINI, G. (1917), *Le ultime scoperte nella chiesa di San Domenico in Chieti*, in *Il Messaggero*, February 8th.

BALISTRERI TRINCANATO, C. (2003), *Guido Cirilli architetto alla Santa Casa di Loreto,* in CHIAPPINI DI SORIO, I., DE ROSSI, L., ed., *Venezia, le Marche e la civiltà adriatica per festeggiare I 90 anni di Pietro Zampetti,* Venice: Edizioni Della Laguna.

BARBATI, G. (1893), *Monografia del castello di Celano*, Casalbordino.

BARTOLOMUCCI, C. (2004), *Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione*, Roma: Palombi.

BATTAGLI, C. (1996), *Il prodigio della Madonna del Duomo,* Falconara: Errebi.

BEER, P., GUIDI, V., MENDITTO, G., PARRA G. (1978), *Esperienza e validità dei sistemi di consolidamento e ristrutturazione di edifici storici e monumentali dissestati dal sisma delle Marche,* in *Atti delle Giornate A.I.C.A.P. 1977. Venezia, 6-9 ottobre 1977*, Roma.

BELLINI, G. M. (1887), *Notizie storiche del celebre Monastero benedettino di San Giovanni in Venere*, Lanciano: Tomassini

BENAZZI, G., CARBONARA, G. (2002), ed., *La cattedrale di Spoleto. Storia Arte Conservazione,* Milan: Federico Motta Editore.

BIOLCHI, R. (1932), *Il problema della cripta della chiesa abbaziale di San Clemente a Casauria*, in *Bollettino d'Arte*, *VII*

BOLOGNA, F. (1986), *S. Clemente al Vomano. Il ciborio di Ruggiero e Roberto*, in *Documenti d'Abruzzo Teramano, II, 1-3. La Valle del medio e basso Vomano,* Rome: De Luca.

BONELLI, R. (1939), *Il palazzo papale di Orvieto,* in *Atti del II Convegno Nazionale di Storia dell'Architettura (Assisi, 1937),* Roma.

BRANCATI, A. (1985), *Vicende architettoniche e strutturali del Teatro Rossini di Pesaro,* Pesaro: Comune di Pesaro.

BRIGANTI, A., MAGNINI, M. (1910), *Perugia, Gubbio, Todi, Umbertide, Mongiovino, Montelabbate, Deruta, Bettona, Castelrigone, Passignano, Cerqueto, Castiglione del Lago: guida storico-artistica,* Perugia: Stab. tip. V. Bartelli.

BROGI, T. (1902), *Memorie di Vico e della chiesa di Santa Maria*, Avezzano: Ed. Angelini

BROGI, T. (1954), *Il santuario ed il castello di Pietraquaria nella Marsica*, Rome: Ist. Grafico Tiberino.

CAFIERO, G. (1968), *La chiesa abbaziale di Santa Maria in Valle Porclaneta. Enigmi di una preziosa chiesa d'Abruzzo*, in *Abruzzo n.2-3.*

CALVANI A. (1968), *La chiesa di Sant'Angelo o Santa Maria Maggiore a Pianella*, in *Napoli nobilissima, I-II.*

CAPEZZALI, W. (2011), ed., *Il palazzo di Margerita d'Austria all'Aquila,* Pescara: Carsa Edizioni.

CAVICCHI, M. (1992), *Nelle terre del Papa: Castel Rigone, Passignano sul Trasimeno, 1860-1970,* Perugia: Il listro.

CECE, F., SANNIPOLI, E. (2000), *Il teatro di Gubbio*, Perugia: EFFE Fabrizio Fabbri editore.

CERASI, U. (2005), *Mezzo secolo di vita, cronaca, cronistoria, arte e ricordi dal 1946 al 2000,* Amelia.

CERASI, U. (2006), *Sintesi di alcuni documenti d'archivio della Curia Vescovile di Amelia liberamente tratti e raccontati da Umberto Cerasi,* Amelia.

CESCHI, C. (1959), *San Pietro in Tuscania,* in *L'Architettura. Cronache e storia,* V.

CHIERICI, U. (1945) a, *I danni della Guerra al patrimonio artistico degli Abruzzi e del Molise,* L'Aquila: Santini.

CHIERICI, U. (1945) b, *Relazione sull'attività dell'Ufficio nel quadriennio 1942-1945,* L'Aquila

CHIERICI, U. (1951), *Il Castello dell'Aquila*, in *Bollettino d'Arte del Ministero della Pubblica Istruzione, a. XXXVI.*

CHIERICI, U. (1964), *La basilica di San Bernardino all'Aquila*, Genova: Effe.

CIGLIA, R. (2009), *Pier Luigi Calore. L'uomo dell'abbazia*, Pescara: Edizioni Tracce – Fondazione Pescarabruzzo.

CIPOLLETTI, C. (2018), *La cattedrale dell'Assunta di Fermo dalla seconda metà del Settecento al Novecento*, in *Marca/Marche. Rivista di storia regionale, II/2018. Storie di comunità. Relazioni, legami, appartenenze e fratture nelle storie di piccoli paesi.*

CIRANNA, S., (2015), *Avezzano tra metamorfosi e cancellazione di una storia urbana,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

CIRANNA, S., MONTUORI, P. (2014) b, *Stefano Bultrini (1867-1936) ingegnere, architetto e urbanista: dall'attività romana tra le due guerre alla ricostruzione della Marsica post-sisma del 1915,* in D'AGOSTINO, S., GIULIO, F., ed., *History of Engineering, Proceedings o International Conference on History of Engineering, V, Convegno di Storia dell'Ingegneria,* Naples: Cuzzolin.

CIRANNA, S., MONTUORI, P. (2015) a, ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915. Città e territori tra cancellazione e reinvenzione*, L'Aquila: Consiglio Regionale dell'Abruzzo.

CIRANNA, S., MONTUORI, P. (2015) b, *Tempo, spazio e architetture. Avezzano cento anni o poco più,* Rome: Artemide.

CIRANNA, S., MONTUORI, P. (2016), *Legno, ferro e cemento armato. Materiali, interventi e presidi antisismici tra L'Aquila, Roma e Avezzano a seguito del sisma del 1915,* in D'AGOSTINO, S., ed., *Storia dell'ingegneria, Atti del 6° convegno internazionale di storia dell'ingegneria,* Naples: Cuzzolin.

CIRANNA, S., MONTUORI, P. (2019), ed., *La storia incontra la scienza tra l'Abruzzo e il Texas. Due anni di attività di scambio e di ricerca avviate nell'ambito dell'accordo bilaterale tra l'Università degli Studi dell'Aquila e l'Università del Texas presso San Antonio*. *History Meets Science between Abruzzo and Texas*. *Two Years of Exchange and Research Activities Undertaken Under the Bilateral Agreement between the University of L'Aquila and the University of Texas at San Antonio*, Rome: Quasar

CLEMENTI, A., PIRODDI, E. (1986), *L'Aquila*. Bari, Laterza.

COLAPIETRA, R. (1998), *Castello Orsini-Colonna*, Avezzano: Di Censo Editore.

CORVI, E. (1978), *Il restauro del Collegio Boccarini ad Amelia,* in *Industria delle Costruzioni, XII, 1978, n. 86*.

CROCE, B. (1894), *Architettura sacra: S. Clemente a Casauria ed altre chiese degli Abruzzi*, in *Napoli nobilissima, fasc. 4°*, in *Sommario critico della storia dell'arte nel napoletano – IV (H)*

D'ANDREA, A. (2010), ed., *Cattedrale Santi Giovenale e Cassio, Narni (Terni): la storia, l'arte, la fede*.

D'ANNUNZIO, G. (1892), *L'Abbazia abbandonata, A Pasquale Villari*, in *Il Mattino*, *a.I*, no. 15, Naples.

DE PATRE, S. (1931), *Le vicende del Duomo di Teramo attraverso i tempi e i restauri*, in *Il popolo di Roma*, September 27th, Rome.

DEL BUFALO, A. (1977), *Il castello Orsini di Avezzano. Storia e restauro. Ricerca svolta in collaborazione con la Soprintendenza ai Monumenti de L'Aquila*, Roma: Bulzoni Editore.

DEL BUFALO, A. (1980), *La basilica di San Bernardino all'Aquila e l'intervento di G.B. Contini*, in *Atti XIX C.*

DELOGU, R. (1948), *Risorta ad Alba Fucens la basilica di San Pietro*, in *Le vie d'Italia, n.8*.

DELOGU, R. (1969), *La chiesa di San Pietro in Alba Fucens e l'architettura romanica in Abruzzo*, in *Alba Fucens, Accademia Belgica*, Rome-Bruxelles.

DEMETRESCU, C. (1997), *Il simbolo nell'arte romanica,* Rimini: Il Cerchio.

DI CIOCCO, P. (1960), *Restauri al castello di Pacentro*, in *Momento-sera*, January 31st.

FARNEDI, G. (2011), *L'Abbazia di San Pietro in Perugia e gli studi Storici,* Cesena: Deputazione di Storia Patria per l'Umbria.

Federico Motta Editore.

FELLI, M. (2019), *Criteria and Methods of Restoration Works in Reinforced Concrete in Abruzzo and Southern Part of United States*, in CIRANNA, S., MONTUORI, P., ed., *La storia incontra la scienza tra l'Abruzzo e il Texas. Due anni di attività di scambio e di ricerca avviate nell'ambito dell'accordo bilaterale tra l'Università degli Studi dell'Aquila e l'Università del Texas presso San Antonio*. *History Meets Science between Abruzzo and Texas*. *Two Years of Exchange and Research Activities Undertaken Under the Bilateral Agreement between the University of L'Aquila and the University of Texas at San Antonio*, Rome: Quasar

FONDEDILE SPA (1973), *Restauro statico dei monumenti,* Napoli.

FONTANA, P. (1848), *Descrizione della chiesa metropolitana di Spoleto del cav. Pietro Fontana*, Spoleto: Presso Vincenzo Rossi.

FRANCHI, B. (1965), *Il rinato castello spagnolo dell'Aquila,* in *L'Osservatore romano della domenica*, October 29th.

FRANZONI, C., SILVI ANTONINI, C. (2007), ed., *L'archivio dell'ufficio del Genio Civile di Terni.* Soprintendenza archivistica per l'Umbria, Scaffali Senza Polvere.

FUCINESE, D.V. (1980) b, *San Liberatore alla Maiella e il problema della ricostruzione desideriana*, in *Atti XIX C.*

FUMI, L. (1896), *Il Palazzo Soliano o de' Papi in Orvieto*, Roma: Tip. dell'Unione Cooperativa Editrice.

GABRIELLI, A. (1923), *Il tempio bramantesco di S. Maria del Sangue in Velletri votivo a memoria dei caduti in guerra: nel 4° centenario della sua erezione,* Velletri: Stab. Tip. Pio Stracca.

GALEOTA, D., ANTONACCI, E., ALOISIO, A., ALAGGIO, R. (2019), *The S. Maria di Collemaggio basilica: from the vulnerability assessment to the first results of SHM,* in *Atti del XVIII Convegno ANIDIS, L'ingegneria sismica in Italia.*

GATTULLI, V., ANTONACCI, E., VESTRONI, F. (2013), *Field observation and failure analysis of the Basilica S. Maria di Collemaggio after the 2009 L'Aquila earthquake,* in *Engineering Failure Analysis,* 34(12), 715-34.

GATTULLI, V., ANTONACCI., E. (2014), *The dynamic behavior of the Basilica S. Maria di Collemaggio before and after the 2009 L'Aquila earthquake,* in CUNHA, A., CAETANO, E., RIBEIRO, G., MULLER, G., ed., *Proceedings of the 9th International Conference on Structural Dynamics, EURODYN.*

GATTULLI, V., POTENZA, F., VALVONA. F. (2015), *Seismic Performance of a Mixed Masonry-Reinforced Concrete Building,* in ASTERIS, P. G., PLEVRIS, V., ed., *Handbook of Research on*

Seismic Assessment and Rehabilitation of Historic Structures, Hershley: Engineering Science Reference.

GAVINI, I. C. (1914), *Un monumento che risorge*, in *Rassegna d'Arte degli Abruzzi e del Molise*, *III, fasc. II,* Teramo: Premiato Stab. Tip. Del Lauro.

GAVINI, I. C. (1924), *L'ambone di San Clemente e una vecchia polemica,* in *Albia: rivista illustrata abruzzese-molisana, I,* Rome: Studio Editoriale Abruzzese-Molisano.

GAVINI, I. C. (1926), *Il restauro della Badia di San Clemente a Casauria*, in *Bollettino d'Arte, IV,* III (September).

GIORGETTI, M. (1994), ed., *Nuovi documenti sui restauri nell'abbazia di San Domenico presso Sora (1875-1914)*.

GRIMALDI, F. (1975), ed., *Basilica Santa Casa,* Bologna: Calderini.

GUIDI, P. (1911), *Il restauro della loggia e del palazzo papale di Viterbo,* in *Ausonia, II,* pp. 117-146.

GUIDI, P. (1932), *La loggia e il palazzo papale di Viterbo*, in *L'Illustrazione vaticana*, III, 5, pp.243-247.

GURRIERI, O. (1964), *La basilica di San Pietro in Perugia: guida illustrata,* Perugia: Azienda autonoma di turismo.

JURGEN, E. (1973), *Das Kastel von L'Aquila degli Abruzzi und sein Arkitekt Pyrrhus Aloisius Scrivà,* in *Romisches Jahrbuch fur Kunstgeschichte,* Band 14.

LIVI, A., SOLLINI, S. (2015), ed., *Fermo sportiva. Giochi competizioni dalle orgini al 1930*, Fermo: Andrea Livi ed.

LOFFREDO, L. (1981), *S. Domenico di Sora e i luoghi natali di Cicerone*, Veroli: Tipografia dell'Abbazia di Casamari.

MALANDRA, B. (2015), *I restauri architettonici e la conservazione delle opere d'arte dopo il sisma del 1915. Il caso di Santa Maria del Ponte presso Tione degli Abruzzi,* in CIRANNA, S., MONTUORI, P., ed., *Avezzano, la Marsica e il circondario a cento anni dal sisma del 1915: città e territori tra cancellazione e reinvenzione,* L'Aquila: Consiglio Regionale d'Abruzzo.

MALENTACCHI, P. (1994), *Paolo Zampi e la reinvenzione di Orvieto medioevale. Il restauro di palazzo Soliano,* in *Ananke: cultura, storia e tecniche della conservazione*, N. 8(1994), pp. 16-25.

MAMMUCARI, R. (2002), *Velletri: viaggio dentro la città: storia, monumenti, chiese, musei, manifestazioni, Velletri sparita*, Velletri: Ve.La.

MANARI, L. (1864), *Basilica di San Pietro,* Perugia: Augusta.

MARANESI, F. (1938), *La cattedrale di Fermo*, in *La Voce delle Marche*, 36, p. 3.

MARCHETTI, L. (2009), *I danni e gli interventi d'urgenza nella Basilica di Collemaggio,* in *Arkos. Scienza e Restauro,* 20, July/September.

MARIANO, F. (1990), *Il Palazzo del Governo di Ancona,* Ancona: Ed. Aniballi.

MARIANO, F. (1993), *Piazza del Papa in Ancona, architettura e scena urbana*, Ancona: Ed. L'Incontro – Confartigianato.

MARINELLI, M. (1961), *L'architettura romanica in Ancona*, Ancona: Camera di commercio industria e agricoltura.

MARTELLI, G. (1965), *Cattedrale di San Giovenale,* in *Bollettino D'Arte, V serie*, I-II, January/June.

MATTHIAE, G. (1959), *Il castello dell'Aquila e il Museo Nazionale abruzzese*, Rome.

MATTHIAE, G. (1963), *San Liberatore alla Maiella e le origini dell'architettura romanica abruzzese*, in *Abruzzo,* no.1-2.

MINISTERO PER I BENI CULTURALI E AMBIENTALI (1998), *Oltre il terremoto - Beyond the earthquake. Marche 1997. Primo repertorio di monumenti danneggiati dal sisma / An initial inventory of monuments damaged in the earthquake,* Roma: Gangemi.

MONTANARI, M. (1996), *Mille anni della chiesa di San Pietro in Perugia e del suo patrimonio*, Foligno.

MORETTI M. (1972) a, *Restauri d'Abruzzo, (1966-1972),* Rome: De Luca Editore.

MORETTI, M. (1972) c, *Collemaggio*, Rome: De Luca Editore.

MORETTI, M., DANDER, M. (1974), *Architettura Civile Aquilana dal XIV al XIX secolo,* L'Aquila: L.U. Japadre Editore.

MORETTI, Ma. (1983), ed., *Chiese di Tuscania,* Novara: Istituto Geografico De Agostini.

MORTARI, L. (1967), *Il museo diocesano di Orte,* Viterbo: Agnesotti

MUNOZ, A., (1916), *Monumenti di Celano prima e dopo il terremoto del 1915*, in *Albia, I n2.*

MURRI, F. (1986), *Santa Giusta e le sue chiese all'Aquila e Bazzano*, L'Aquila: Marcello Ferri.

NATALUCCI, M. (1966), *Visita al Duomo di Ancona e breve itinerario nella città di Ancona*, Città di Castello: Unione Arti Grafiche.

PAGANI, G. (1968), *Avezzano e la sua storia*, Casamari: Tipografia Abbazia Casamari.

PALMIERI, D.A. (1965), *La chiesa di Santa Maria Assunta di Tione degli Abruzzi attraverso la documentazione storica*, L'Aquila: Lussostampa del Romano.

PARDI, R. (1971), *Il restauro del Palazzo papale di Orvieto,* in *Storia e arte in Umbria nell'età comunale, Atti del VI convegno di Studi Umbri. Gubbio, 26-30 maggio 1968*, Perugia: Università di Perugia.

PARENTE, P. (1912), *Per l'Abbazia di San Clemente a Casauria,* in *Arte e Storia*, ser. 5A no. 11.

PARLATO, E. (2001), *Santa Maria Maggiore a Tuscania*, in PARLATO, E., ROMANO, S., ed., *Roma e il Lazio. Il Romanico*, Milano: Jacka Book, Roma: Palombi.

PENNA L., ROBBA, G. (1980), *Il duomo di Teramo*, in *Atti XIX C.*

PERALI, P. (1919), *Orvieto. Note storiche di topografia. Note storiche d'arte dalle origini al 1800,* Orvieto: M. Marsili.

PERISSINOTTO, C. (1998), ed., *San Giovenale: la Cattedrale di Narni nella storia e nell'arte: atti del Convegno di studi, Narni, 17-18 ottobre 1996,* Narni: Centro di Studi Storici.

PEROTTI, R. (1949), *Il Castello di Celano nella storia e nell'arte della Marsica*, Rome: Nardini.

PICCIRILLI, P. (1889), *Santa Maria in Valle Porclaneta presso Rosciolo (Marsica),* in Rassegna abruzzese di storia e di arte, no.7.

PINZI, C. (1889), *Storia della città di Viterbo,* Rome: Tipografia Camera dei Deputati.

PIRANI, V. (1998), *Le chiese d'Ancona,* Ancona: Edizione dell'Arcidiocesi d'Ancona e Osimo.

PIROCCHI, T. (1908), *Per l'isolamento del duomo di Teramo*, in *L'Abruzzo letterario*, no.23.

POLICHETTI CANTI, M. L. (1981), *Santa Maria della Piazza*. Ancona: Sagraf.

POLICHETTI CANTI, M. L. (2003), *San Ciriaco. La Cattedrale di Ancona. Genesi e sviluppo*.

POLICHETTI, M. L. (1985), ed., *Il palazzo di Federico da Montefeltro: Restauri e ricerche (volume 1) - Rilievi (volume 2),* Urbino: Quattroventi Edizioni.

POLVERARI, M. (1994), ed., *Ancona Pontificia - l'Ottocento in un inventario urbano*, Ancona: Comune di Ancona.

POZZO, A., (1931), *La Mole Antonelliana,* in *Confederazione Nazionale Sindacati Fascisti Professionisti e Artisti, X,* no.2, November, pp. 15-21

RASICCI, P. (1912), *Completati i lavori di restauro di un monumento paleocristiano. Anteriore al Mille la chiesa di S. Maria a Vico,* in *Il Messaggero (cronaca di Teramo),* January 12th.

RASICCI, P. (1972), *Restaurata la chiesa di S. Maria a Vico*, in *Il Giornale d'Abruzzo e Molise,* Teramo, February 21st.

RASPI SERRA, J. (1971), *Tuscania. Cultura ed espressione artistica di un centro medioevale*, Banco di Santo Spirito – ERI.

RASPI SERRA, J. (1972), *La Tuscia romana. Un territorio come esperienza d'arte: evoluzione urbanistico-architettonica,* Electa- Banco di Santo Spirito.

RICCI, F. (1996), *Tuscania: Chiesa di Santa Maria Maggiore,* Viterbo: Betagamma.

RICCOBONI, A. (1933) a, *I grandiosi restauri del Duomo di Teramo,* in *L'illustrazione vaticana, D*ecember 12th, pp. 33-38.

RICCOBONI, A. (1933) b, *Vicende e fasti del duomo di Teramo*, in *Teramo, boll. mensile del Comune*, September-October.

RIGHETTI TOSTI CROCE, M. (1978), *La chiesa di Santa Maria Maggiore di Lanciano: un problema dell'architettura italiana del Duecento,* in *I Cistercensi e il Lazio*, Rome.

RIVERA, G. (1902), *La chiesa di Santa Maria del Ponte nel Comune di Fontecchio parrocchia di Tione*, in *Bollettino della Deputazione Abruzzese di Storia Patria*, L'Aquila.

RODIROSSI, A. (1983), *Ascoli Piceno città d'arte,* Modena: "Stampa & Stampa" Gruppo Euroarte Gattei, Grafiche STIG.

ROMEO, P. (1967), *Santa Maria in Valle Proclaneta chiesa romanica del secolo XI*, Edizione Centenari, s.1.

ROSSO, F. (1977), *Alessandro Antonelli e la Mole di Torino,* Turino: Stampatori.

ROTONDI, P. (1951), *Il palazzo ducale di Urbino, vol. 1-2*, Urbino: Istituto Statale d'Arte per il Libro.

ROZZI, N. (1913), *I quattro campanili fratelli di Teramo, Atri, Campli, Corropoli illustrati da 12 tavole di cui 8 fototipie su disegni dell'Ing. Quintino Rozzi*, Teramo: Fabbri.

SANDRI, L. (1985), ed., *Il Palazzo Benincasa in Ancona,* Roma: Istituto Nazionale delle Assicurazioni.

SANGUINETTI, F. (1961), *La ex chiesa di S. Silvestro a Orte e il suo campanile,* in *Bollettino d'arte, 1961, I-II, Gennaio Febbraio, 159*.

SANTARELLI, G. (2003), *La Santa Casa di Loreto*, Loreto: Edizioni lauretane.

SAVINI, F. (1900), *Il duomo di Teramo. Storia, e descrizione corredate di documenti e di XIX tavole fototipiche*, Rome: Forzani.

SAVINI, F. (1926) a, *A proposito dei restauri del Duomo.* Lecter in *Il popolo abruzzese*, August 21st.

SAVINI, F. (1926) b, *Ancora per i restauri del Duomo di Teramo.* Lecter in Il popolo Abruzzese, September 11th.

SAVINI, F. (1926) c, *Il restauro del Duomo di Teramo,* in *L'Italia centrale,* July 24th-25th.

SAVINI, F. (1929), *I restauri della chiesa di S. Domenico. Le ignoranze dell'Araldo abruzzese e la verità dei fatti*, in *Il solco*, June 30th.

SAVINI, F. (1931), *Il restauro di S. Domenico di Teramo nello stile originario romanico-gotico (1929-1931). Relazione storico-artistica*, Teramo: Cioschi.

SCATENA, O. (2001), *Casa San Luca e l'Antico Eremo di Sant'Agnello in Guarcino,* Altopascio: Marinari.

SCIPIONI, D. (1935), *Brevi notizie storico-artistiche sulla chiesa di S. Lucia Vergine e Martire in Magliano Dei Marsi*, Rome: Tip. Madre di Dio.

SCRIATTOLI, A. (1920), *Viterbo e i suoi monumenti,* Viterbo: Buffetti.

SEBASTIANI, S. (1996), *L' anfiteatro romano di Ancona*, Ancona.

SERRA, L. (1911), *Santa Giusta di Bazzano*, in Bollettino della Deputazione Abruzzese di Storia Patria.

SORDINI, G. (1908), *Il Duomo di Spoleto: delle origini, secondo i documenti*, Spoleto: Panetto & Petrelli.

STACCINI, E. (2005), *Tuscania. Guida ai monumenti. I monumenti principali con cenni alla storia, alle tradizioni, breve bibliografia e servizi,* Tuscania.

TOMASSINI, C. (2016), *Fermo: la cattedrale dell'Assunta,* available at http://www.luoghifermani.it/?p=6022

TOSCANO, B. (1969), *Il duomo di Spoleto,* Spoleto: Edizioni dell'Ente Rocca di Spoleto.

TOSTI, G. (1976), *Considerazioni sul restauro,* Spoleto: Arti Grafiche Panetto & Petrelli.

TRECCO, D. (1981), *Quattro passi pe' ll'Aquila de 'na 'ote,* Rome: Fratelli Palombi Editori

TRIZIO, I. (2008), *La Chiesa di Santa Maria in Valle Porclaneta*, in FIORANI, D., ed., *Finiture murarie e architetture nel medioevo. Una panoramica e tre casi di studio dell'Italia centro-meridionale,* Rome Gangemi.

TRIZIO, I. (2017), *La Chiesa di Santa Maria in Valle Porclaneta. La vicenda storico-costruttiva e l'uso di strumenti innovative per la gestione della conoscenza,* Florence: Nardini Editore.

VALENTINO, D. (1975), *Il restauro del Palazzo Papale di Orvieto,* in *Bollettino d'Arte del Ministero per i Beni Culturali e Ambientali, LX 1975, 3-4.*

VALENTINO, D. (1975), *Note sul restauro del Lazzaretto di Castelrigone,* in *Bollettino d'arte, V serie, III-IV, Luglio, Dicembre,* 213.

VERLENGIA, F. (1958), *I ruderi di San Liberatore alla Maiella,* in *Rivista abruzzese*, no.1.

VERLENGIA, F. (1967), *Il campanile di San Giustino in Chieti*, in *Abruzzo-supplemento*, I.

WITTKOWER, R. (1954), *Il tempietto di Santa Maria del Sangue a Velletri e il suo restauro,* in *Palladio: rivista bimestrale di storia dell'architettura,* 9, IV, n.1-2, pp. 85-89.

ZAMPETTI, P. (1963), *Il Palazzo ducale di Urbino e la Galleria nazionale delle Marche*, Roma.

ZECCA, V. (1858), *Memorie storiche artistiche della Badia di S. Spirito sul monte Maiella e un'appendice sulla Badia del Morrone presso Sulmona*, Naples: All'Insegna del Diogene.

ZEITZ, K. L. (2005), *Italian Opera Houses and Festivals*, Lanham, Maryland: The Scarecrow Press, Inc.

ZIGNOLI, V. (1961), *La ricostruzione della Mole Antonelliana,* in *Rassegna Tecnica,* A.15, no. 9, September.

Specific Bibliography for the American Case Studies

(1900), *Mission memories. The Franciscan Mission of California*, Los Angeles: Kingsley-Barnes & Neuner Company

(1921), *Spanish Missions to be Restored,* in *The American Architect (1909-1921),* February 23rd. San Antonio

(1997), *A Comparison of the Mission Systems of Baja and Alta California,* in *Pacific Coast Archaeological Society Quarterly 33*, no. 3 (Summer 1997): pp. 1-28.

ABLES, L. R. (1967), *The Second Battle of the Alamo,* in *Southwestern Historical Quarterly,* LXX (3), pp. 372-413.

ALESSIO ROBLES, V. (1993), *Franciscan Evangelization in Spanish Frontier Texas: Apex of Social Contact, Conflict, and Confluence, 1751-1761,* in *Colonial Latin American Historical Review* 2 (Summer 1993): pp. 253-287.

ALESSIO ROBLES, V. (1996), *The Return of the Franciscans to Texas, 1891-1931,* in *Catholic Southwest: A Journal of History and Culture 6:* pp. 91-114.

ALMARAZ, Jr F. D. (1993), *Franciscan Evangelization in Spanish Frontier Texas: Apex of Social Contact, Conflict, and Confluence, 1751-1761*, in *Colonial Latin American Historical Review* 2 (Summer 1993): pp. 253-287.

ALMARAZ, Jr F. D. (1996), *The Return of the Franciscans to Texas, 1891-1931,* in *Catholic Southwest: A Journal of History and Culture* 6: pp. 91-114.

ALMARAZ, Jr F. D. (1997), *Misiones Franciscanas de Nuevo México y El Paso del Norte a Través del Camino Real*, in *El Camino Real de Tierra Adentro: Historia y Cultura*, Chihuahua: Instituto Nacional de Antropología e Historia/National Park Service (1997): pp. 223-229.

ALMARAZ, Jr F. D. (2003), *Faith along a River: Franciscan Missions of Spanish Colonial San Antonio, 1718-1836,* Draft located in San Antonio Mission National Historic Park Library.

AUGUSTIN, FATHER O.F.M. (1925), *New Mission Plans Told. First Restoration Works Soon Begins on Church Proper at Santa Barbara,* in *Los Angeles Times,* July 15th

AVITES, B. A., HOOVER, R. L. (1997), *Two Californias, Three Religious Orders and Fifty Missions:*

BAER, K. (1958), *Architecture of the California Missions,* Berkeley California: University of California Press.

BAER, K. (1961), *Spanish Colonial art in the California Missions,* in *The Americas,* 18, n.1.

BANCROFT, H. H. (1963), *History of California,* San Francisco: History Company

BARR, A. (1996), *Black Texans: A history of African Americans in Texas, 1528–1995* (2nd ed.). Norman, OK: University of Oklahoma Press.

BATZ, R. (1933), *The acquisition and restoration of the San José Mission Granary by the San Antonio Conservation Society, 1924-1933,* San Antonio Texas: San Antonio Conservation Society.

BECKETT, E. B. (1880), *A book on building civil and ecclesiastical: including church restoration with the theory of domes and the great pyramid, and dimensions of many churches and other great buildings,* London: Crosby Lockwood and Co.

BENOIST, H., FLORES, M. E. (1994), ed., *Documents Relating to the Old Spanish Missions of Texas. Volume I.* San Antonio, Texas: Old Spanish Missions Historical Research Library, Our Lady of the Lake University.

BRACKEN, D. K., REDWAY, M. W. (1956), *Early Texas Homes,* Dallas: Southern Methodist University Press.

BROWN, W. (2018), *Reconstructing Historic Landmarks. Fabrication, Negotiation, and the Past,* Research in Architectural Conservation and Historic Preservation, New York: Routledge.

CHAPMAN, C. E. (1936), *a History of California: The Spanish Period,* New York: The Macmillan Company.

COFFEE, K. (2011), *Archaeology of Standing Buildings Survey of the Mission San Juan de Capistrano Chapel. Bexar County, Texas, USA,* Master thesis in School of Archaeology & Ancient History.

CORBIN, J. E. (1989), *Spanish-Indian Interaction on the Eastern Frontier of Texas,* in THOMAS, D. H. (ed), *Columbian Consequences, Vol. 1, Archaeological and Historical Perspectives on the Spanish Borderlands West,* Washington and London: Smithsonian Institution Press.

CORREIRA, J. (2006), *Conservation of the Sacristy Window: San José y San Miguel de Aguayo,* San Antonio, Texas: San Antonio Mission National Historic Park Library.

DE ZAVALA, A. (1917), *History and legends of the Alamo and other missions in and around San Antonio,* San Antonio: Standard Printing Co.

EARLY, J. (2004), *Presidio, Mission, and Pueblo: Spanish Architecture and Urbanism in the United States, Dallas Texas: Southern Methodist University Press.*

EATON, J. D. (1980), *Excavation at the Alamo Shrine (Mission San Antonio de Valero),* Special Report. No. 10, San Antonio: Center for Archaeological Research, The University of Texas at

EDMONDSON, J.R. (2000). *The Alamo Story-From History to Current Conflicts.* Plano, TX: Republic of Texas Press

ENGELHARDT, Z., O.F.M. (1922), *San Juan Capistrano Mission*, Los Angeles: Standard Printing Co.

ENGELHARDT, Z., O.F.M. (1929), *San Miguel Archangel: The Mission of the Highway,* Santa Barbara California.

ENGELHARDT, Z., O.F.M. (1931), *Mission San Juan Bautista: A School of Church Music,* Santa Barbara California.

ENGELHARDT, Z., O.F.M. (1963), *Mission San Luis Obispo in the Valley of the Bears,* Santa Barbara California.

ENGELHARDT, Z., O.F.M. (1973), *Mission Fernando Rey: The Mission of the Valley of the Valley,* Ramona California: Ballena Press.

ENOCHS, R., (2006), *The Franciscan Mission to the Navajos: Mission Methods and Indigenous Religion, 1898-1940,* in *The Catholic Historical Review,* vol. 92, no. 1 (January), pp. 46-73.

FELLI, M., CIRANNA, S. (2019), *Le missioni francescane in California. Il "Camino Real", un riferimento identitario di architettura e restauro. Franciscan Missions in California. "El Camino Real", an Identitary Reference of Architecture and Preservation,* in *CIRICE 2018. VIII Convegno Internazionale di Studi / VIII International Conference,* Naples: Federico II University Press

FELLI, M., CIRANNA, S., LOMBARDI, A. (2019), *The Shrine of the Alamo and Its Roof: History and Strategies of Recovering,* in *World Heritage and Legacy, XVII International Forum "Le Vie Dei Mercanti"*, Conference Proceedings, Rome: Gangemi.

FISHER, L. F. (1996), *Saving San Antonio: The Precarious Preservation of a Heritage,* Lubbock, Texas: Texas Tech University Press.

FISHER, L. F. (1997), *San Antonio: Outpost of Empires,* San Antonio: Maverick Publishing Company.

FISHER, L. F. (1998), *The Spanish Missions of San Antonio,* San Antonio: Maverick Publishing Company.

FLORES, R. R. (2002), *Remembering the Alamo. Memory, Modernity, and the Master Symbol,* Austin: University of Texas Press.

FORD POWELL & CARSON (2003), *San Antonio Missions: Condition Assessment and Preservation Analysis, Volume II: Mission San José y San Miguel de Aguayo,* Architectural Report for the San Antonio Missions National Historical Park, Special Libraries.

GERALD, R. E. (1968), *Spanish Presidios of the Late Eighteenth Century in Northern New Spain,* Museum of New Mexico Research Records No. 7, Santa Fe: Museum of New Mexico Press.

GRAFFLY, (2010), *Historic Santa Barbara. An illustrated history,* San Antonio: National Publishing Network.

GRONEMAN, B. (1990). *Alamo Defenders, A Genealogy: The People and Their Words*. Austin, TX: Eakin Press

HABIG, M. A. (1968) a, *The Alamo Chain of Missions. A history of San Antonio's Five Old Missions,* Chicago: Franciscan Herald Press.

HABIG, M. A. (1968) b, *San Antonio's Mission San José: State and National Historic Site, 1720-1968*. San Antonio: The Naylor Company.

HABIG, M. A. (1977), *The Alamo Mission, San Antonio de Valero, 1718-1793,* Chicago: Franciscan Herald.

HANNAFORD, D. (1931), *Spanish-Colonial or Adobe Architecture of California,* Architectural Book Publishing.

HARING, C. H. (1947), *The Spanish Empire in America,* New York: Oxford University Press.

HATA, N, (1992), *The Historic Preservation Movement in California, 1940-1976,* Sacramento: California Department of Parks and Recreation.

HEUSINGER, D. W. (1951), *A Chronology of Events in San Antonio,* San Antonio Texas: Standard Printing Co.

HITCHCOCK, H. R. (1946), *American Architectural Books: A List of books, portfolios and pamphlets on Architecture and related subjects published in America before 1895,* 3rd ed., Minneapolis: University of Minnesota Press.

IVEY, J. E. (2007), *The Completion of the Church Roof of San Antonio de Valero,* in *Anales del Instituto de Investigacionec Estiticas, vol. XXIX,* No. 91, Distrito Federal Mexico: Instituto de Investigaciones Esteticas, pp. 125-153

IVEY, J. E., FOX, A. A. (1997), *Archaeological and Historical Investigations at the Alamo North Wall. San Antonio, Bexar County, Texas,* San Antonio: Center for Archaeological Research. The University of Texas at San Antonio. Archaeological Survey Report, No. 224.

IVEY, J. E., THRUBER, M.B., ESCOBEDO, S. (2006), *Of Various Magnificence: The Architectural History of the San Antonio Mission in the Colonial Period and the Nineteenth Century, Volume 1*, National Park Service Professional Papers No. 11, Santa Fe. Manuscript on file, Center for Archaeological Research, The University of Texas at San Antonio.

IVEY, J. E., THURBER, M. B. (1984), *The Missions of San Antonio: A Historic Structures Report and Administrative History: Part 1-The Spanish Colonial Missions*, National Park Service, Southwest Cultural Resources Center. Draft report on file at the Center for Archaeological Research, The University of Texas San Antonio.

JAMES AND SUAREZ, (1995), *Mission San Jose Cultural Landscape Report, Report prepared for U.S. Department of Interior*.

JENNINGS, P. C., HOUSNER, G. W. (1973), *The San Fernando, California, Earthquake of February 9, 1971,* in *Proceedings of the Fifth*. Rome: World Conference on Earthquake Engineering.

JOHNSON, P. C. (1964), *The California Missions: A Pictorial History,* Menlo Park California: Lane Book Company.

KIMBRO, E. E., COSTELLO, J. G., BALL, T. (2009), *The California Missions: History, Art and Preservation,* Los Angeles: The Getty Conservation Institute.

KRELL, D. (1979), ed., *The California Missions,* Menlo Park California: Lane Publishing Company.

KRYDER-REID, E. (2010), *"Perennially New". Santa Barbara and the Origins of the California Mission Garden,* in Journal of the Society of Architectural Historians, 69, no. 3 (September).

LEFFINGWELL, R. (2005), *California Missions and Presidios: The History & Beauty of the Spanish Missions,* Stillwater: Voyageur Press, Inc.

MEISSNER, B. A. (1996), *The Alamo Restoration and Conservation Project: Excavations at the South Transept,* Archaeological Survey Report, No. 245. Center for Archaeological Research, The University of Texas at San Antonio.

NELSON, G. S. (1998), *The Alamo: an illustrated history*.

NEWCOMB, P. (1926), *The Alamo City,* San Antonio Texas: Pearson Newcomb

NEWCOMB, R. (1914), *Architecture of the California Missions,* in *Annual Publication of the Historical Society of Southern California,* vol. 9, no. 3, pp. 225-235.

NEWCOMB, R. AIA (1937), *Spanish-colonial architecture in the United States,* New York City: J.J. Augustin.

PEDELTY, M. (1992), *The New California Mission System: Museums, Gift Shops, and Historical Archaeologies,* in *Kroeber Anthropological Society Papers,* no. 73-74, pp. 80-91.

SAN ANTONIO MISSIONS NATIONAL HISTORICAL PARK (1995), *Mission San Jose. Cultural Landscape Report,* San Antonio National Park Service – Southwest Region, November.

SAVAGE, C.E. (1991), *New Deal Adobe: The Civilian Conservation Corps and the Reconstruction of Mission la Purisima, 1934-1942,* Santa Barbara California: Fithian Press.

SCHOELWER, S. P. (1985), *Alamo Images: Changing Perceptions of a Texas Experience*. Dallas, TX: The DeGlolyer Library and Southern Methodist University Press.

SCHUETZ-MILLER, M. K. (1987), *Architectural Practice in Mexico City: A Manual for Journey-man Architects of the Eighteenth Century,* Tucson: University of Arizona Press.

SCHUETZ-MILLER, M. K. (1994), *Building and Builders in Hispani California, 1769-1850,* Tucson Arizona: Southwestern Mission Research Center; Santa Barbara California: Santa Barbara Trust or Historic Preservation, Presidio Reseach Publication.

SCHUETZ-MILLER, M. K. (2003), *The Geometry of San Xavier del bac and La Purisima Concepcion de Nuestra Senora de Caborca,* in *Journal of the Southwest,* vol. 45, no. 1/2, Architecture (Spring-Summer), pp. 263-268.

SCHUYLER, M. (1961), *American Architecture and Other Writings,* Cambridge: The Belknap Press of Harvard University.

SEWALL, J. M., A.I.A. (2013), *California Mission Architecture. A Survey and Sourcebook,* Atglen, Pennsylvania: Schiffer Publishing, Ltd.

TODISH, T. J., TODISH, T., SPRING, T. (1997), *Alamo Sourcebook, 1836: A Comprehensive Guide to the Battle of the Alamo and the Texas Revolution*. Austin, TX: Eakin Press.

VROMAN, A.C. (1900), *Mission Memories. The Franciscan Missions of California,* Los Angeles: Kingsley-Barnes & Neuner Company.

WALTERS, P. H. (1951), *Secularization of the La Bahia Missions,* in *The Southwestern Historical Quarterly,* vol. 54, no. 3 (January), Texas Historical Association, pp. 287-300

WEBER, F. J., Msgr. (2005), *The California Missions,* Strasbourg Editions du Signe.

WEDDLE, R. S. (1968), *San Juan Bautista: Gateway to Spanish Texas.* Austin: University of Texas Press.

WEINBERG, N. G. (1974), *1945. Historic Preservation and tradition in California: The Restoration of the Missions and the Spanish-colonial Revival,* PhD Dissertation, University of California, Davis.

CONSULTED ARCHIVES

Public and Private Archives in Italy

- **ACS** | Central State Archive of Rome
- **ASGCReg.** | Historical Archive of the Genio Civile of L'Aquila (in the State Archive of L'Aquila)
- **ASGCReg.Az** | Historical Archive of the Genio Civile of Avezzano
- **ASSA** | Historical Archive of Soprintendenza Archeologia, Belle Arti e Paesaggio per l'Abruzzo, L'Aquila
- **ASSA.Avezzano** | Historical Archive of Soprintendenza Archeologia, Belle Arti e Paesaggio per l'Abruzzo, section of Avezzano
- **AFSABAP** | Historical Photographical Archive of Soprintendenza Archeologia, Belle Arti and Paesaggio of Abruzzo, L'Aquila
- **ASAq** | State Archive of L'Aquila
- **ASAq.Avezzano** | State Archive of Avezzano
- **ASAq.Sulmona** | State Archive of Sulmona
- **ASC.Avezzano** | Historical Archive of the Municipality of Avezzano
- **ASC.Celano** | Historical Archive of the Municipality of Celano
- **ASC.L'Aquila** | Historical Archive of the Municipality of L'Aquila (in State Archive of L'Aquila)
- **ASC.Magliano** | Historical Archive of the Municipality of Magliano De' Marsi
- **ADM** | Diocesan Archive of Marsi, in Avezzano
- **CADS** | Archival Complex of the Diocese of Sulmona

- **AS.BAR** | Historical Private Archive of the Company Barattelli of L'Aquila
- **AS.STI** | Historical Private Archive of the Studio Tecnico Inverardi

Online sources

- **ASD.Corriere** | Historical Archive of *Corriere Della Sera* newspaper
- **ICCD** | Central Institute for the Catalogue and the Documentation

Public and Private Archives in United States

- **DRT** | Historical Archive of the Daughters of Republic of Texas, San Antonio
- **HASA** | Historical Archive of the Bexar County, San Antonio TX
- **GLO** | Historic Archive of the General Land Office, Austin TX
- **NPSSA** | National Park Service Historical Archive, San Antonio TX

Online sources

- **HABS** | The Historic American Building Survey, Library of Congress
- **LIBC** | The Library of Congress
- **MMA** | Metropolitan Museum of Art, Digital Collection
- **NYPL** | The New York Public Library. Digital Collections
- **SACS** | San Antonio Conservation Society, The Portal to Texas History
- **SBMA** | Santa Barbara Mission Archive-Library
- **SJHS** | San Juan Bautista Historical Society
- **TSA** | The Texas State Archive
- **UCLA** | Los Angeles Times Archive
- **UCSC** | University of California, Los Angeles. -- Library. -- Dept. of Special Collections (repository)
- **USC** | University of South California Libraries, Special Collections
- **UTA_AAA** | The Alexander Architectural Archive, The University of Texas at Austin
- **UTSA** | UTSA Libraries. Special Collections

LIST AND SOURCES OF IMAGES

Cover: *Mission of San José y San Miguel Aguayo, San Antonio (TX),* front façade, photo by author (2017).

Chap. 1 | Reinforced Concrete as a Solution to the Static Problem

Front page: *Interior of the Basilica of San Clemente a Casauria, Castiglione a Casauria, Italy*. FELLI, M. (2019), Criteria and Methods of Restoration Works in Reinforced Concrete in Abruzzo and Southern Part of United States, in CIRANNA, S., MONTUORI, P., ed., History Meets Science between Abruzzo and Texas. Two Years of Exchange and Research Activities Undertaken Under the Bilateral Agreement between the University of L'Aquila and the University of Texas at San Antonio, Rome: Quasar

Fig. 1_1: *Map of seismic risk of Central Italy, expressed in terms of ground peck acceleration, probability of excess of 10% in fifty years. (INGV)* Istituto Nazionale Geofica e Vulcanologia, Interactive Seismic Hazard Maps, http://esse1-gis.mi.ingv.it/s1_en.php?restart=0

Fig. 1_2: *Map of the Franciscan Mission of California in comparison to the San Andreas' Fault. (Toppozada, 2004)*. TOPPOZADA, T., BRANUM, D. (2004), California earthquake history, in Annals of Geophysics, vol. 47, no. 2/3, April/June.

Fig. 1_3: *Church of Santa Maria Maggiore in Tuscania after the earthquake of 1971.* From the web. https://i.ebayimg.com/images/g/NBYAAOSwilxaCX5P/s-l1600.jpg

Fig. 1_4: *Church of San Ciriaco, detail of the main gate after the earthquakes of 1952.* From the web, https://www.comune.ancona.gov.it/ankonline/ankonmagazine/2017/06/14/45-anni-dal-terremoto-di-ancona/

Fig. 1_5: *The Franciscan Missions in San Antonio Texas (2019)*. FELLI, M. (2019), Criteria and Methods of Restoration Works in Reinforced Concrete in Abruzzo and Southern Part of United States, in CIRANNA, S., MONTUORI, P., ed., History Meets Science between Abruzzo and Texas. Two Years of Exchange and Research

Activities Undertaken Under the Bilateral Agreement between the University of L'Aquila and the University of Texas at San Antonio, Rome: Quasar

Fig. 1_6: *El Camino Real: the 21 Franciscan missions in Alta California (Sewall, 2013).* SEWALL, J. M., A.I.A. (2013), California Mission Architecture. A Survey and Sourcebook, Atglen, Pennsylvania: Schiffer Publishing, Ltd.

Fig. 1_7: *Historical Map of the strongest earthquake (from Mg. 5.5 Richter) which interested California since the 19th century (Toppozada, 2004).* TOPPOZADA, T., BRANUM, D. (2004), California earthquake history, in Annals of Geophysics, vol. 47, no. 2/3, April/June.

Fig. 1_8: *Characteristics of the "Hennebique system" structures in a logo for postal envelopes of the Porcheddu company (1912).* GUARISCO, G., ACITO, M., CUSATELLI, S., RAJABI, M. (2019), Camillo Boito's "Capannone" for the Accademia di Brera in Milan: Reuse of a Railway Depot, in DELLA TORRE, S., BOCCIARELLI, M., DAGLIO, L., NERI, R., ed., Buildings for Education. Research for Development. Springer, Cham

Fig. 1_9: *Aerial view of Avezzano after the earthquake of 1915 (Mastroddi, 2005).* MASTRODDI, M. (2005), L'altra Avezzano, Avezzano: Comune di Avezzano.

Fig. 1_10: *Aerial view of San Francisco after the earthquake of 1906.* From the web: http://robroy.dyndns.info/lawrence/landscape.html

Chap. 2 | Theories and Laws

Front page: *Loggia dei Papi of the Archbishop Palace in Viterbo before the restoration of 1904 (1860).* VALTIERI, S. (2005), I restauri della Loggia papale di Viterbo, in DELLA COSTA M., CARBONARA, G., ed., Memoria e restauro dell'Architettura, Saggi in onore di Salvatore Boscarino, Milan: Ex Fabrica, Franco Angeli.

Fig. 2_1: *The Loggia dei Papi in Viterbo before the restoration intervention (end of 19th century) (Scriattoli).* SCRIATTOLI, A. (1920), Viterbo e i suoi monumenti, Viterbo: Buffetti.

Fig. 2_2: *Elevation drawing of the loggia. Project (Valtieri).* VALTIERI, S. (2005), I restauri della Loggia papale di Viterbo, in DELLA COSTA M., CARBONARA, G., ed., Memoria e restauro dell'Architettura, Saggi in onore di Salvatore Boscarino, Milan: Ex Fabrica, Franco Angeli.

Fig. 2_3: *Section drawing of the reinforced concrete beam (1911).* VALTIERI, S. (2005), I restauri della Loggia papale di Viterbo, in DELLA COSTA M., CARBONARA, G., ed., Memoria e restauro dell'Architettura, Saggi in onore di Salvatore Boscarino, Milan: Ex Fabrica, Franco Angeli.

Fig. 2_4: *Detail drawing for the restoration project of the eighty years, which identify the inserted reinforced concrete beam (Valtieri).* VALTIERI, S. (2005), I restauri della Loggia papale di Viterbo, in DELLA COSTA M., CARBONARA, G., ed., Memoria e restauro dell'Architettura, Saggi in onore di Salvatore Boscarino, Milan: Ex Fabrica, Franco Angeli.

Fig. 2_5: *The Loggia dei Papi today. From the web: https://www.goticomania.it/gotico-italiano/palazzo-dei-papi-viterbo.html*

Fig. 2_6: *One of the numerous photomontage of the tower bell's collapse.* From the web: http://www.tryitaly.com/wp-content/uploads/2018/10/Campanile-San-Marco-crollo.jpg

Fig. 2_7: *Reconstruction works of the tower bell of San Marco in Venice (1908).* (1908), La ricostruzione del Campanile di Venezia e della Loggetta del Sansovino, in Bollettino d'Arte, VII, July.

Fig. 2_8: *Reconstruction works of the tower bell of San Marco (1911) (LIBC).* The Library of Congress. FOREIGN GEOG FILE - Italy--Venice--Architecture [item] [P&P]. Library of Congress Prints and Photographs Division Washington, D.C. 20540 USA Digital Id cph 3c31722 //hdl.loc.gov/loc.pnp/cph.3c31722.

Fig. 2_9: *The tower bell of San Marco rebuilt in 1912 (LIBC).* The Library of Congress. FOREIGN GEOG FILE - Italy--Venice--Architecture [item] [P&P] Repository Library of Congress Prints and Photographs Division Washington, D.C. 20540 USA. Digital Id cph 3c31723 //hdl.loc.gov/loc.pnp/cph.3c31723.

Fig. 2_10: *The spire of Mole Antonelliana during the work of Thirty years.* ROSSO, F. (1977), Alessandro Antonelli e la Mole di Torino, Turino: Stampatori.

Fig. 2_11: *Interior of the Mole Antonelliana at the end of the work in the Thirty years.* ROSSO, F. (1977), Alessandro Antonelli e la Mole di Torino, Turino: Stampatori.

Fig. 2_12: *New structure of the Mole Antonelliana, designed by the engineer Pozzo (1931).* POZZO, A., (1931), La Mole Antonelliana, in Confederazione Nazionale Sindacati Fascisti Professionisti e Artisti, X, no.2, November, pp. 15-21

Fig. 2_13: *Section drawing of the Mole with the actual state at 1953 (1961).* ZIGNOLI, V. (1961), La ricostruzione della Mole Antonelliana, in Rassegna Tecnica, A.15, no. 9, September.

Fig. 2_14: *The Mount Vernon Ladies' Association. First group of participants.* From the web: https://www.mountvernon.org/preservation/mount-vernon-ladies-association/

Fig. 2_15: *Capitol building in Williamsburg after the renovation works. (1934-ca. 1950).* Collection: A. D. White Architectural Photographs, Cornell University Library. Available at: http://library24.library.cornell.edu/collections/adw/75706-10040169.html

Fig. 2_16: *Alfred Giles in 1898.* HOLLERS GEORGE, M. C. (2006), The Architectural Legacy of Alfred Giles. Selected Restoration, San Antonio TX: Trinity University Press.

Fig. 2_17: *The office of Alfred Giles Company in about 1910.* HOLLERS GEORGE, M. C. (2006), The Architectural Legacy of Alfred Giles. Selected Restoration, San Antonio TX: Trinity University Press.

Chap. 3 | Restoration Strategies in Central Italy

Front page: *Stone elements of the Church of San Pietro in Alba Fucens removed after the earthquake of 1915*. (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_1: *General plan of the Basilica of San Clemente by Gavini.* GAVINI, I. C. (1926), Il restauro della Badia di San Clemente a Casauria, in Bollettino d'Arte, IV, III (September).

Fig. 3_2: *Interior of the basilica before the restoration intervention.* GAVINI, I. C. (1926), Il restauro della Badia di San Clemente a Casauria, in Bollettino d'Arte, IV, III (September).

Fig. 3_3: *Section drawing of the fist hypothesis of the restoration of Basilica of San Clemente by Gavini.* GAVINI, I. C. (1926), Il restauro della Badia di San Clemente a Casauria, in Bollettino d'Arte, IV, III (September).

Fig. 3_4: *Section drawing and plan of the restoration project of the basilica of San Clemente by Gavini. (Miarelli Mariani).* MIARELLI MARIANI, G. (1979), Monumenti nel tempo. Per una storia del restauro in Abruzzo e nel Molise, Rome: Carucci Editore.

Fig. 3_5: *Differences of the main nave view before and after the restoration (Miarelli Mariani)*. MIARELLI MARIANI, G. (1979), Monumenti nel tempo. Per una storia del restauro in Abruzzo e nel Molise, Rome: Carucci Editore.

Fig. 3_6: *View of the presbyterian area after the restoration (1926).* GAVINI, I. C. (1926), Il restauro della Badia di San Clemente a Casauria, in Bollettino d'Arte, IV, III (September).

Fig. 3_7: *View of the presbyterian area after the restoration (1992).* CARBONARA, G. (1997), Avvicinamento al restauro. Teoria, storia, monumenti, Napoli: Liguori.

Fig. 3_8: *View of façade of the church of Santi Giovanni Battista e Evangelista in Celano after the earthquake of 1915.* R. SOPRINTENDENZA ai Monumenti di Roma e degli Abruzzi (1915), I danni dell'arte nei paesi battuti dal terremoto del 13 gennaio 1915, in Bollettino d'Arte, II, Supplemento n. 1.

Fig. 3_9: *View of interior of the church of Santi Giovanni Battista e Evangelista in Celano after the earthquake of 1915.* R. SOPRINTENDENZA ai Monumenti di Roma e degli Abruzzi (1915), I danni dell'arte nei paesi battuti dal terremoto del 13 gennaio 1915, in Bollettino d'Arte, II, Supplemento n. 1.

Fig. 3_10: *Façade of the church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.* Private Collection.

Fig. 3_11: Aerial view of the church of Santa Lucia after the earthquake of 1915. Private Collection.

Fig. 3_12: *Façade of the church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.* Private Collection.

Fig. 3_13: *Aerial view of the church of Santa Lucia after the earthquake of 1915.* Private Collection.

Fig. 3_14: *Church of Santa Lucia in Magliano De' Marsi after the earthquake of 1915.* Private Collection.

Fig. 3_15: *Plan of the restoration project by Sabatini (1926, ASGCReg.Az)*. Historical Archive of the Genio Civile of Avezzano. B. 24, f.7. Classe A4 chiese con parrocchie. Magliano Dei Marsi. Chiesa Parrocchiale di Santa Lucia.

Fig. 3_16: *Façade of the restoration project by Sabatini (1926, ASGCReg.Az)*. Historical Archive of the Genio Civile of Avezzano. B. 24, f.7. Classe A4 chiese con parrocchie. Magliano Dei Marsi. Chiesa Parrocchiale di Santa Lucia.

Fig. 3_17: *Detail of the reinforcement of the arches by the engineer Pietrangeli (1938, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano. B. 24, f.7. Classe A4 chiese con parrocchie. Magliano Dei Marsi. Chiesa Parrocchiale di Santa Lucia.

Fig. 3_18: *Detail of the foundation (1938, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano. B. 24, f.7. Classe A4 chiese con parrocchie. Magliano Dei Marsi. Chiesa Parrocchiale di Santa Lucia.

Fig. 3_19: *Detail of the reinforced concrete trusses (1938, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano. B. 24, f.7. Classe A4 chiese con parrocchie. Magliano Dei Marsi. Chiesa Parrocchiale di Santa Lucia.

Fig. 3_20: *The Piccolomini Castle of Celano after the earthquake of 1915.* (2000), Il Castello Piccolomini di Celano, L'Aquila: Soprintendenza ai ambientali e architettonici artistici e storici per l'Abruzzo.

Fig. 3_21: *Interior of the Piccolomini Castle f Celano after the bombardments of 1944*. (2000), Il Castello Piccolomini di Celano, L'Aquila: Soprintendenza ai ambientali e architettonici artistici e storici per l'Abruzzo.

Fig. 3_22: *Elevation of the main façade of the Piccolomini Castle. Restoration project (1954, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano. B 987, Celano. Castella Piccolomini, opera riparazione 1o lotto (1954-1958). Fasc. Prog. Rip.b 987.

Fig. 3_23: *Section drawing of the restoration project. Detail of the truss in reinforced concrete (1954, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano.

B 987, Celano. Castella Piccolomini, opera riparazione 1o lotto (1954-1958). Fasc. Prog. Rip.b 987.

Fig. 3_24: *Section drawing of the restoration project. Detail of the truss in reinforced concrete (1957, ASGCReg_Az.* Historical Archive of the Genio Civile of Avezzano. B 988, Celano. Castella Piccolomini, opera riparazione 2o lotto (1955-1961).

Fig. 3_25: *Section drawing of the restoration project with the elements to be reconstructed. (1954, ASGCReg_Az).* Historical Archive of the Genio Civile of Avezzano. B 987, Celano. Castella Piccolomini, opera riparazione 1o lotto (1954-1958). Fasc. Prog. Rip.b 987.

Fig. 3_26: *The scaffoldings on the façade of the basilica.* CINGOLI, G. (1990), ed., Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti, Teramo: Edigrafital.

Fig. 3_27: *Positioning of the steel bars of the top beam.* CINGOLI, G. (1990), ed., Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti, Teramo: Edigrafital.

Fig. 3_28: *Section drawing of the reinforced concrete frame of the façade (in which it is possible to see the four orders of bond and top beams).* CINGOLI, G. (1990), ed., Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti, Teramo: Edigrafital.

Fig. 3_29; Fig. 3_30: *Pictures during the survey of the upper part of the façade.* CINGOLI, G. (1990), ed., Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti, Teramo: Edigrafital.

Fig. 3_31; Fig. 3_32; Fig. 3_33: *Realization of the top beam and connection to the column of the facade: positioning of the connecting bars, positioning of the bond beam bars, pouring of the concrete.* CINGOLI, G. (1990), ed., Cingoli: dal '33 consolidamento e restauro: Abruzzo monumenti, Teramo: Edigrafital.

Fig. 3_34: *Church of Sant'Orante after the earthquake of 1915.* DONATELLI, A. (2010), Terremoto e architettura storica. Prevenire l'emergenza, Rome: Gangemi.

Fig. 3_35: *The church with the provisional structure in timber (front) (1960, (ASGCReg_Az).* Historical Archive of the Genio Civile of Avezzano. B 83m, Ortucchio, fasc. 2. Chiesa di Sant'Orante (Prog. Restauro).

Fig. 3_36: *The church of Sant'Orante with the provisional structure in timber ("lantern") (1960, ASGCReg_Az).* Historical Archive of the Genio Civile of Avezzano. B 83m, Ortucchio, fasc. 2. Chiesa di Sant'Orante (Prog. Restauro).

Fig. 3_37 - Fig. 3_38: *Restoration drawings by Delfini and Bevilacqua. Front façade and transversal section.* Historical Archive of the Genio Civile of Avezzano. B 83m, Ortucchio, fasc. 2. Chiesa di Sant'Orante (Prog. Restauro).

Fig. 3_39 - Fig. 3_40: *Restoration drawings by Galvani and Dander. Front façade and transversal section (1968, ASGCReg_Az).* Historical Archive of the Genio Civile of Avezzano. B 83m, Ortucchio, fasc. 2. Chiesa di Sant'Orante (Prog. Restauro).

Fig. 3_41: *Restoration drawing by Galvani and Dander. Longitudinal section (1968, ASGCReg_Az)*. Historical Archive of the Genio Civile of Avezzano. B 83m, Ortucchio, fasc. 2. Chiesa di Sant'Orante (Prog. Restauro).

Fig. 3_42: *Section drawing of the reinforcement of the loggia of the first level (1973)*. CARBONARA, G. (1981), ed., Restauro e cemento in architettura, Roma: Associazione Italiana Tecnico Economica del Cemento.

Fig. 3_43: *Section drawing of the reinforcement of the loggia of the second level (1973).* CARBONARA, G. (1981), ed., Restauro e cemento in architettura, Roma: Associazione Italiana Tecnico Economica del Cemento.

Fig. 3_44: *Reinforcement of the ceiling of the apse during the restoration works (1980).* CARBONARA, G. (1981), ed., Restauro e cemento in architettura, Roma: Associazione Italiana Tecnico Economica del Cemento.

Fig. 3_45: *The façade of Collemaggio in 1880-1885 in a drawing by Leosini.* LEOSINI, A. (1974), Monumenti storici artistici della città di Aquila e i suoi contorni, Bologna: Forni.

Fig. 3_46: *Interior of Collemaggio in 1890 from a postcard.*

Fig. 3_47: *The façade of Collemaggio during the deassemblation works of 1915. (ASSA).* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi

Fig. 3_48: *The façade of Collemaggio after the deassemblation of 1915. (ASSA)* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi.

Fig. 3_49: *The façade after the deassemblation (1915-1920).* TRECCO, D. (1981), Quattro passi pe' ll'Aquila de 'na 'ote, Rome: Fratelli Palombi Editori.

Fig. 3_50: *Sketches by Biolchi showing the damages of the façade and the provisional structures. (ASSA).* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi

Fig. 3_51: *Sketches of the structural reinforcement by Biolchi (ASSA).* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi

Fig. 3_52: *Scheme of the reinforced concrete frame of the façade (ACS).* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi

Fig. 3_53: *Transversal section drawing of the restoration project by Biolchi (ASSA).* BARTOLOMUCCI, C. (2004), Santa Maria di Collemaggio. Interpretazione critica e problemi di conservazione, Roma: Palombi

Fig. 3_54: *Interior of Collemaggio before the intervention of Moretti.* MORETTI, M. (1972) c, Collemaggio, Rome: De Luca Editore.

Fig. 3_55 - Fig. 3_56 - Fig. 3_57: *Interior of Collemaggio before the intervention of Moretti. Details of the removal of the baroque stuccos.* MORETTI, M. (1972) c, Collemaggio, Rome: De Luca Editore.

Fig. 3_58: *Comparison plans between the previous version of Collemaggio and the new one after Moretti's intervention.* MORETTI, M. (1972) c, Collemaggio, Rome: De Luca Editore.

Fig. 3_59: *Comparison transversal sections in both directions between the old (left) and new (right) versions of Collemaggio*. MORETTI, M. (1972) c, Collemaggio, Rome: De Luca Editore.

Fig. 3_60: *The church of San Pietro in Albe before the earthquake of 1915.* MUNOZ, A. (1915), I monumenti del Lazio e degli Abruzzi danneggiati dal terremoto, in Bollettino d'arte, II-IV, February-April.

Fig. 3_61: *Interior of the church of San Pietro. Detail of the iconostasys.* MUNOZ, A. (1915), I monumenti del Lazio e degli Abruzzi danneggiati dal terremoto, in Bollettino d'arte, II-IV, February-April.

Fig. 3_62: *Interior of the church of San Pietro in Albe after the earthquake of 1915.* R. SOPRINTENDENZA ai Monumenti di Roma e degli Abruzzi (1915), I danni dell'arte nei paesi battuti dal terremoto del 13 gennaio 1915, in Bollettino d'Arte, II, Supplemento n. 1.

Fig. 3_63: *Interior of the church of San Pietro in Albe after the earthquake of 1915; first phase of the interior's liberation from the ruins.* Video from Soprintendenza ABP.

Fig. 3_64: *View of the apse collapsed with the earthquake*. (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_65: *Interior of the church of San Pietro in Albe during the first phase of liberation from the ruins.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_66: *Interior of the church of San Pietro in Albe during the first phase of liberation from the ruins. Detail of the ambon.* Video from Soprintendenza ABP.

Fig. 3_67: *Interior of the church of San Pietro in Albe after the liberation from the ruins.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_68 - Fig. 3_69: *Workers during the deassemblation of the elements and the cataloguing.* Video from Soprintendenza ABP.

Fig. 3_70: *View of the main gate of the church after the liberation of the interior from the ruins.* Video from Soprintendenza ABP.

Fig. 3_71: *The interior of the church after the liberation.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_72: *View of the apse after the removing of the decaying elements.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_73: *The disassembled elements of the church.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_74: *The columns before be punctured for the insertion of reinforcement bars.* Video from Soprintendenza ABP.

Fig. 3_75: *The columns during the puncture for the insertion of the steel bars.* Video from Soprintendenza ABP.

Fig. 3_76: *Axonometric restitution of the new reinforced concrete structure.* (1991), La chiesa di San Pietro in Alba Fucense, Soprintendenza per i beni ambientali e architettonici artistici e storici per l'Abruzzo, in Collana "Quaderni Didattici", n. 10.

Fig. 3_77: *Axonometric restitution of the new reinforced concrete structure, with the identification of horizontal and vertical frames.* MIARELLI MARIANI, G. (1979), Monumenti nel tempo. Per una storia del restauro in Abruzzo e nel Molise, Rome: Carucci Editore.

Fig. 3_78: *Article in the Corriere della sera by Cesare Brandi in 1957.* BRANDI, C. (1957), Uno sgomentante puzzle risolto per amore dell'arte, in Corriere della Sera, December 27th.

Chap. 4 | Case Studies in United States

Front page: *Interior of the Mission of San Antonio de Valero, commonly renown as the Alamo (HABS)*. 20. Historic American Buildings Survey, October, 1961 NAVE, LOOKING EAST. - Mission San Antonio de Valero, Alamo Plaza, San Antonio, Bexar County, TX. 5 x 7 in. | Boucher, Jack E.

Fig. 4_1: *El Camino Real. Map of the 21 Franciscan Missions of California (1903).* Mabel Emerton Prentiss. Published by Mrs. S. A. P. Wheeler, San Gabriel, California. *(from the web)*

Fig. 4_2: *The villa and presidio of San Antonio de Bexar: together with the Franciscan Missions (1939).* Library of Congress Geography and Map Division Washington, D.C. 20540-4650 USA dcu *(from the web)*

Fig. 4_3: *Scheme of the Franciscan Missions, with the realization of the constructions next to the local villages (2009).* KIMBRO, E. E., COSTELLO, J. G., BALL, T. (2009), The California Missions: History, Art and Preservation, Los Angeles: The Getty Conservation Institute.

Fig. 4_4 a/b: *The Franciscan Mission of Santa Barbara in California (NYPL). Postcards of the exterior and church interior.* The Miriam and Ira D. Wallach Division of Art, Prints and Photographs: Photography Collection. Detroit Publishing Company postcards.

Fig. 4_5: *The cover page of the novel "Ramona", the flier for the enrollment in the CCC, the spot of a lemonade with the mission of San Fernando in the back (Kimbro, 2009).* KIMBRO, E. E., COSTELLO, J. G., BALL, T. (2009), *The California Missions: History, Art and Preservation,* Los Angeles: The Getty Conservation Institute.

Fig. 4_6: *Interior of Mission San Fernando in ca. 1812 (1900)*. (1900), Mission memories. The Franciscan Mission of California, Los Angeles: Kingsley-Barnes & Neuner Company.

Fig. 4_7: *The San Juan mission after the earthquake of 1906 with the collapse of the convento's walls.* Photograph from the San Juan Bautista Historical Society.

Fig. 4_8: *The interior of the church of San Juan from a picture of 1900*. (1900), *Mission memories. The Franciscan Mission of California*, Los Angeles: Kingsley-Barnes & Neuner Company.

Fig. 4_9: *Section drawing of the church of San Juan in 1934. It is possible to individuate the additions in reinforced concrete, as the buttresses and the base thickening of the walls (HABS).* HABS CAL,35-SAJUB,1- (sheet 12 of 38) - Mission San Juan Bautista, Second Street, San Juan Bautista Plaza, San Juan Bautista, San Benito County, CA. 19 x 24 in. (B size)

Fig. 4_10: *Section detail drawing of the church of San Miguel Archangel (HABS).* HABS CAL,40-SANMI.V,1- (sheet 21 of 36) - Mission San Miguel Archangel, Highway 101, San Miguel, San Luis Obispo County, CA.

Fig. 4_11: *Front elevation of the mission, with the narthex (HABS).* HABS CAL,40-SANLO,1- (sheet 2 of 11) - Mission San Luis Obispo de Tolosa, 782 Monterey Street, San Luis Obispo, San Luis Obispo County, CA. 19 x 24 in. (B size)

Fig. 4_12: *Section drawing of the mission of San Luis Obispo (HABS).* HABS CAL,40-SANLO,1- (sheet 2 of 11) - Mission San Luis Obispo de Tolosa, 782 Monterey Street, San Luis Obispo, San Luis Obispo County, CA 19 x 24 in. (B size)

Fig. 4_13: *Painting depicting the grounds of the Mission San Luis Obispo, c.a.1865 (USC)*. Credits: Pierce, C.C. (Charles C.), 1861-1946; Pierce, C.C. (Charles C.), 1861-1946. Digitally reproduced by the USC Digital Library; From the California Historical Society Collection at the University of Southern California.

Fig. 4_14: *The refurbished mission of San Louis in 1905, with its adobe walls covered in wooden siding and the façade without the narthex (Kimbro, 2009*. KIMBRO, E. E., COSTELLO, J. G., BALL, T. (2009), The California Missions: History, Art and Preservation, Los Angeles: The Getty Conservation Institute.

Fig. 4_15: *Section Detail Drawing of the Mission of San Fernando (HABS).* HABS CAL,19-SANF,2B- (sheet 8 of 8) - Mission San Fernando Rey de Espana, Church, Mission Road, San Fernando, Los Angeles County, CA. 19 x 24 in.

Fig. 4_16: *Plan of the mission San Luis Obispo with plan details of the narthex (HABS).* HABS CAL,40-SANLO,1- (sheet 3 of 11) - Mission San Luis Obispo de Tolosa, 782 Monterey Street, San Luis Obispo, San Luis Obispo County, CA.

Fig. 4_17: *The Alamo after the battle of 1836 in a drawing from the war report by capt. George Hughes (TSA).* 103-598, Places Collection, Prints and Photographs Collections. Archives and Information Services, Texas State Library and Archives Commission.

Fig. 4_18: *The second floor of the Alamo church, with the new roof in timber due the works of 1851(GLO).* General Land Office, Austin. Alamo works.

Fig. 4_19: *Photograph of Alamo Plaza in 1880s. (Photograph of DRT, from Meissner.* MEISSNER, B. A. (1996), *The Alamo Restoration and Conservation Project: Excavations at the South Transept,* Archaeological Survey Report, No. 245. Center for Archaeological Research, The University of Texas at San Antonio.

Fig. 4_20: *The Alamo works of 1920 with the scaffoldings on the facade (photo from DRT)*. Daughters of Republic of Texas Historical Archive, San Antonio.

Fig. 4_21: *Interior of the Alamo in a sketch by Alfred Giles Studio (1920)*. From San Antonio Evening News, *newspaper,* January 30th 1920.

Fig. 4_22: *The Alamo façade in the reconstruction drawing by Henry T. Phelps (1936).* Alexander Architectural Archive. Reconstruction drawings by Henry T. Phelps, 1936 (mis057-mis062)

Fig. 4_23: *The mission of Santa Barbara in 1876*. Old Mission Church from the eastern foothills, Santa Barbara; Albumen Silver Print 1876 Metropolitan Museum of Art, Carleton Watkins (1829–1916).

Fig. 4_24: *The mission of Santa Barbara after the earthquake of 1925 (UCLA)*. Published in the July 1, 1925, Los Angeles Times, photograph by: George Watson / Los Angeles Times Archive.

Fig. 4_25: *Picture of Mission Santa Barbara after the earthquake of 1925.* Los Angeles Times Photographic Archive. Department of Special Collections, Charles E. Young Research Library.

Fig. 4_26 - Fig. 4_27: *Pictures of Mission Santa Barbara after the earthquake of 1925. Detail of the tower bell.* Los Angeles Times Photographic Archive. Department of Special Collections, Charles E. Young Research Library.

Fig. 4_28 - Fig. 4_29: *Pictures of Mission Santa Barbara after the earthquake of 1925 (Graffly, 2010)*. GRAFFLY, (2010), Historic Santa Barbara. An illustrated history, San Antonio: National Publishing Network.

Fig. 4_30: *Picture of Mission Santa Barbara during the restoration works, during the assembly of the scaffoldings in 1926 (UCLA).* Los Angeles Times Archive

Fig. 4_31: *Picture of Mission Santa Barbara during the restoration works, with the scaffoldings in 1926 (UCLA).* Los Angeles Times Archive

Fig. 4_32: *General plan of the mission of Santa Barbara (HABS).* HABS CAL,42-SANBA,5- (sheet 3 of 30) - Mission Santa Barbara, 2201 Laguna Street, Santa Barbara, Santa Barbara County, CA. 19 x 24 in. (B size).

Fig. 4_33: *Section drawing of mission Santa Barbara (HABS).* HABS CAL,42-SANBA,5- (sheet 8 of 30) - Mission Santa Barbara, 2201 Laguna Street, Santa Barbara, Santa Barbara County, CA. 19 x 24 in. (B size).

Fig. 4_34: *Detail plan of the convento's spaces (HABS).* HABS CAL,42-SANBA,5- (sheet 8 of 30) - Mission Santa Barbara, 2201 Laguna Street, Santa Barbara, Santa Barbara County, CA. 19 x 24 in. (B size).

Fig. 4_35: *Picture of the façade of the church, after the collapses of the interior (TSA).* 1964/306-781, Photographs, Graham (R. Niles) collection. Archives and Information Services Division, Texas State Library and Archives Commission.

Fig. 4_36: *Picture of the church before the collapses. (from the web)*

Fig. 4_37: *Picture of painting with the main gate, after the collapses of the interior (TSA).* 1/103-635, Places Collection, Prints and Photographs Collections. Archives and Information Services, Texas State Library and Archives Commission.

Fig. 4_38: *Picture of the mission of San Jose after the collapse of the dome in 1924. (TSA)*. 1969/072-22, Owen Wister photograph collection. Archives and Information Services Division, Texas State Library and Archives Commission.

Fig. 4_39: *Interior of the church after the collapse of the interiors (Ford Powell and Carson)*. FORD POWELL & CARSON (2003), San Antonio Missions: Condition Assessment and Preservation Analysis, Volume II: Mission San José y San Miguel de Aguayo, Architectural Report for the San Antonio Missions National Historical Park, Special Libraries.

Fig. 4_40: *Aerial view of the mission with the collapsed church in 1924 (Ford Powell and Carson)*. FORD POWELL & CARSON (2003), San Antonio Missions: Condition Assessment and Preservation Analysis, Volume II: Mission San José y San Miguel de Aguayo, Architectural Report for the San Antonio Missions National Historical Park, Special Libraries.

Fig. 4_41: *Interior of the church after the collapse (Ford Powell and Carson)*. FORD POWELL & CARSON (2003), San Antonio Missions: Condition Assessment and Preservation Analysis, Volume II: Mission San José y San Miguel de Aguayo, Architectural Report for the San Antonio Missions National Historical Park, Special Libraries.

Fig. 4_42: *Spectators view the debris of the bell tower that suddenly collapsed on March 9, 1928 (UTSA)*. UTSA Libraries. Special Collections. *This photograph was published the following day with an article stating that Catholic Archbishop Arthur J. Drossaerts had already appointed an architect to plan an immediate reconstruction to be financed by the archdiocese. (MS 359: -L-0282-C)*.

Fig. 4_43: *Section drawing with the state of the church after the collapse of the dome and the roof (by Robert Leon White, UTA_AAA)*. Drawings used to illustrate thesis: Mission Architecture of Texas by Robert Leon White, 1930 (mis074-mis083).

Fig. 4_44: *Section drawing of the restoration project by Harvey Smith. Detail of the ceiling vaults in reinforced concrete (1934-1936). (UTA_AAA)*. Church and convent restoration drawings by Harvey P. Smith, 1934-1936.

Fig. 4_45: *Restoration drawings by Harvey Smith. Details of the elements and frames in reinforced concrete (1934). (NPSSA)*. Historical Archive National Park Service of San Antonio.

Fig. 4_46: *Restoration drawings by Harvey Smith. Detail of the arch in reinforced concrete (1934). (NPSSA)*. Historical Archive National Park Service of San Antonio.

Fig. 4_47: *Restoration drawings by Harvey Smith. Details of the elements in reinforced concrete and scheme of the new dome. (1934). (NPSSA)*. Historical Archive National Park Service of San Antonio.

Fig. 4_48: *Restoration drawings by Harvey Smith. Details of the new dome. (1934). (NPSSA)*. Historical Archive National Park Service of San Antonio.

Fig. 4_49: *A massive frame scaffold sits beside the church during reconstruction of the tower (April 1928 (UTSA)*. UTSA Libraries. Special Collections (MS 359: L-0512-01)

Fig. 4_50: *Civil Works Administration employees prepare to rebuild the north wall of the mission church, February 1934 (UTSA)*. UTSA Libraries. Special Collections (MS 359: L-0207-A)

Fig. 4_51: *Fortified gate constructed by Civil Works Administration employees from plans by restoration architect Harvey Smith, February 1934. It is possible to see the bell tower reconstructed. (UTSA)*. UTSA Libraries. Special Collections (MS 359: L-207-E)

Fig. 4_52: *Scaffolding covers the entrance to the church while a waterproofing compound is applied to the carved stone façade, (November 1935) (UTSA)*. UTSA Libraries. Special Collections (MS 359: L-0836-A)

Fig. 4_53: *Scaffoldings and works on the dome (1936) (HABS)*. Historic American Buildings Survey, Arthur W. Stewart, Photographer, September 23, 1936 SOUTHEAST ELEVATION OF COURTYARD. - Mission San Jose y San Miguel de Aguayo, Mission Road, San Antonio, Bexar County, TX

Fig. 4_54: *Lateral view during the reconstruction of the dome (1936) (HABS)*. Historic American Buildings Survey, Arthur W. Stewart, Photographer, September 18, 1936 SOUTH ELEVATION. - Mission San Jose y San Miguel de Aguayo, Mission Road, San Antonio, Bexar County, TX 5 x 7 in. HABS TEX,15-SANT.V,5--2 | HABS TEX,15-SANT.V,5—2

Fig. 4_55: *Worker beside the model, painted with reproductions of the geometric designs that once covered the walls of the church and convento, July 1933 (UTSA)*. UTSA Libraries. Special Collections (MS 359: L-1424-K)

Chap. 5 | The Structural Aspect of the Restorations

Front page: *Interior of Collemaggio with the collapsed reinforced concrete beam after the earthquake of 2009*. ANTONACCI, E., GATTULLI, V., MARTINELLI, A., VESTRONI, F. (2010), Il crollo del transetto della Basilica di Collemaggio: analisi di vulnerabilità e meccanismo di collasso, in Atti del workshop: Sicurezza e conservazione dei beni culturali colpiti da sisma: Strategie e tecniche di ricostruzione ad un anno dal terremoto abruzzese.

Fig. 5_1: *Sketch which accompanied the letter to the superintendent about the necessity of intervention on the Loggia dei Papi in 1956.* VALTIERI, S. (2005), I restauri della Loggia papale di Viterbo, in DELLA COSTA M., CARBONARA, G., ed., Memoria e restauro dell'Architettura, Saggi in onore di Salvatore Boscarino, Milan: Ex Fabrica, Franco Angeli.

Fig. 5_2: *Damages on the Castle of L'Aquila after 2009 quake event. The top beams pushed out of the plane the masonry.* MARCHETTI, L., MILANO, L., MORISI,

C., CALDERINI, C., DONATELLI, A. (2011), L'università e la ricerca per l'Abruzzo. Il patrimonio culturale dopo il terremoto del 6 aprile 2009, L'Aquila: Textus.

Fig. 5_3: *Cathedral of San Massimo after the quake event of 2009. After the collapse of the dome, there is still present the top beam in reinforced concrete.* MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_4 - Fig. 5_5: *Cathedral of San Massimo after the quake event of 2009. Removal of the hanging elements in reinforced concrete*. MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_6: *Mission San Miguel Archangel in 1936.Front Façade (HABS).* 17. Photocopy of photograph (from Mr. William H. Knowles Collection, 1936) Photographer unknown, Date unknown VIEW OF EXTERIOR, 1936 - Mission San Miguel Archangel, Highway 101, San Miguel, San Luis Obispo County, CA 5 x 7 in. HABS CAL,40-SANMI.V,1--17 | HABS CAL,40-SANMI.V,1—17

Fig. 5_7: *Mission San Miguel Archangel after the earthquake of 2003.*Picture from web: https://s.hdnux.com/photos/11/22/27/2434502/7/920x920.jpg

Fig. 5_8: Mission San Miguel Archangel today (2019). Picture from the web: *https://www.tripsavvy.com/mission-san-miguel-arcangel-1478431*

Fig. 5_9: *Mission San Fernando Rey in 1880.* Carleton Watkins (American, 1829 - 1916) (1829 - 1916) – photographer (American) about 1880 Albumen silver. Height: 203 mm (7.99 in). Width: 314 mm (12.36 in). WAHSSOPkaaaGfQ at Google Cultural Institute.

Fig. 5_10: *Mission San Fernando Rey in 1936 (HABS).* 1. Historic American Buildings Survey Photographed by H. F. Withey April 22nd, 1934. CHURCH FROM THE WEST. #1. - Mission San Fernando Rey de Espana, Church, Mission Road, San Fernando, Los Angeles County, CA 4 x 5 in. HABS CAL,19-SANF,2B--1 | HABS CAL,19-SANF,2B—1

Fig. 5_11: *Mission San Fernando Rey in 1880.* From the web: http://www.fortwiki.com/Mission_San_Fernando_Rey_de_Espana

Fig. 5_12: *Conceptual representation of the in-plan eccentricity between center of masses (GM) and center of stiffness (GK).* CRESPI, P., FRANCHI, A., GIORDANO, N., RONCA, P., SCAMARDO, M. (2015), The basilica of Collemaggio in L'Aquila: seismic assessment analysis, in BARROS, H., LOJA, A., FERREIRA, C., BARBOSA, J. I., ADAM, J. M., FRAGIACOMO, M., MARI., A. R., ed., International Conference on Recent Advances in Rehabilitation and Sustainability of Structures. RehabStructures.

Fig. 5_13 - Fig. 5_14: *The collapsed area of Collemaggio with the reinforced concrete elements hanging.* MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_15: *The collapsed transept areas with the hollow elements in the masonry due to the falling of top beams.* MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_16: *The collapsed area of the transept (in the red boxes there are the reinforced concrete top beams).* ANTONACCI, E., GATTULLI, V., MARTINELLI, A., VESTRONI, F. (2010), Il crollo del transetto della Basilica di Collemaggio: analisi di vulnerabilità e meccanismo di collasso, in Atti del workshop: Sicurezza e conservazione dei beni culturali colpiti da sisma: Strategie e tecniche di ricostruzione ad un anno dal terremoto abruzzese.

Fig. 5_17: *The remains of the triumphal arch pillar.* GALEOTA, D., ANTONACCI, E., ALOISIO, A., ALAGGIO, R. (2019), The S. Maria di Collemaggio basilica: from the vulnerability assessment to the first results of SHM, in Atti del XVIII Convegno ANIDIS, L'ingegneria sismica in Italia.

Fig. 5_18: *The collapsed area of Collemaggio with the reinforced concrete elements hanging and the top beams visible due to the detachment of the plaster.* MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_19: *Interior of Collemaggio with the provisional structures after the earthquake; view from the transept. It is possible to see the top beam in reinforced concrete on the left, at "middle height" of the wall of the main nave.* MARCHETTI, L., ALTORIO, E. (2013), ed., MiSAQ. Mese in Sicurezza all'Aquila dopo il terremoto del 6 aprile 2009, Avezzano: Officina Multimedia Abruzzo.

Fig. 5_20: *Interior of Collemaggio with the provisional structures after the earthquake, view from the nave,* from the web: https://www.cittanuova.it/la-basilica-collemaggio-restituita-agli-aquilani/?ms=005&se=003

Fig. 5_21: *Individuations of the interventions among the areas of study,* by author.

Fig. 5_22: *Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila,* by author.

Fig. 5_23 – Fig. 5_24 – Fig. 5_25: *Example of form (Case study A_1|1: Basilica of Santa Maria di Collemaggio in L'Aquila, Details of the form,* by author.

Conclusions

Front page: *Interior of Collemaggio with the new columns in reinforced concrete during the restoration interventions.* GALEOTA, D., ANTONACCI, E., ALOISIO, A., ALAGGIO, R. (2019), The S. Maria di Collemaggio basilica: from the vulnerability assessment to the first results of SHM, in Atti del XVIII Convegno ANIDIS.

Fig. 6_1: *The foundation of the new pillar in reinforced concrete of the reconstructed area.* GALEOTA, D., ANTONACCI, E., ALOISIO, A., ALAGGIO, R. (2019), The S. Maria di Collemaggio basilica: from the vulnerability assessment to the first results of SHM, in Atti del XVIII Convegno ANIDIS, L'ingegneria sismica in Italia.

Fig. 6_2: *The new pillar in reinforced concrete, realized in the reconstructed area.* GALEOTA, D., ANTONACCI, E., ALOISIO, A., ALAGGIO, R. (2019), The S. Maria di Collemaggio basilica: from the vulnerability assessment to the first results of SHM, in Atti del XVIII Convegno ANIDIS, L'ingegneria sismica in Italia.

Fig. 6_3: *Interior of Collemaggio today. The differences of materials between the original walls of the nave (left) and transept (right),* by author (2017).

Appendix

Front page: *Church of Santa Lucia in Magliano De' Marsi in 1902 (ICCD).* Gabinetto Fotografico Nazionale, Archivio negativi, inventario C001043, author Gargiolli, Giovanni.

Sources

Front page: *Mission San José y San Miguel Aguayo, San Antonio, Texas. Detail (HABS, 1983).*DETAIL OF OLD PLASTER COVERING, SOUTH WALL OF FRONT TOWER - Mission San Jose y San Miguel de Aguayo, Church, 6539 San Jose Road, San Antonio, Bexar County, TX 1983 | 4 x 5 in. | Lowe, Jet HABS TEX,15-SANT,V,5E--20 (CT) | HABS TEX,15-SANT,V,5E--20 (CT).

UNIVERSITA' DEGLI STUDI DELL'AQUILA
Dipartimento di Ingegneria Civile, Edile-Architettura, Ambientale

Ph.D.ICEAA | Dottorato di Ricerca in Ingegneria Civile, Edile-Architettura, Ambientale
XXXII ciclo

Coordinatore del dottorato
Prof. Marcello Di Risio

Tutor
Prof.ssa Simonetta Ciranna

Candidato
Ing. Marco Felli